INTERAVIA

REVIEW OF WORLD AVIATION

IN THIS ISSUE

Tactical Missiles

Convair 880/600 Jetliner

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VOLUME XIII

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INTERAVIA

Review of World Aviation

Volume XIII **No. 11** **November 1958**

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The smaller twin-spool J-52, whose commercial version is the JT8, is in the medium power range. This 7500 pound-thrust engine is slated to power a new missile, and a new twin-engined attack fighter.

Smallest and newest is the JT12, a simply-built,

rugged, efficient engine that reflects Pratt & Whitney's extensive engine-building experience. The JT12 weighs only 430 pounds, yet due to its advanced design it produces 2900 pounds of dry static thrust. With a single spool and fixed geometry, the JT12 promises outstanding performance, reliability and ease of maintenance for many possible applications.

Meanwhile at Pratt & Whitney Aircraft's research and development centers in Connecticut and Florida development continues on the powerful new J-58 engine, and various aircraft propulsion systems of the future are being explored or developed. When the time comes, they will be ready to take their places as working members of the world's "first family" of power plants for flight.

"FIRST FAMILY" of the jet world now includes four axial-flow jet engines, all pictured here. At left, the famous J-57; with afterburner it develops over 15,000 pounds-thrust. The commercial version (without afterburner) is the JT3. At far right is the bit J-75 with afterburner, which produces over 20,000 pounds-thrust. Commercial version (without afterburner) is the JT4. Bottom center is the 7500 pound-thrust J-52. Behind it is the new JT12, appearing almost tiny besides its powerful big brothers.

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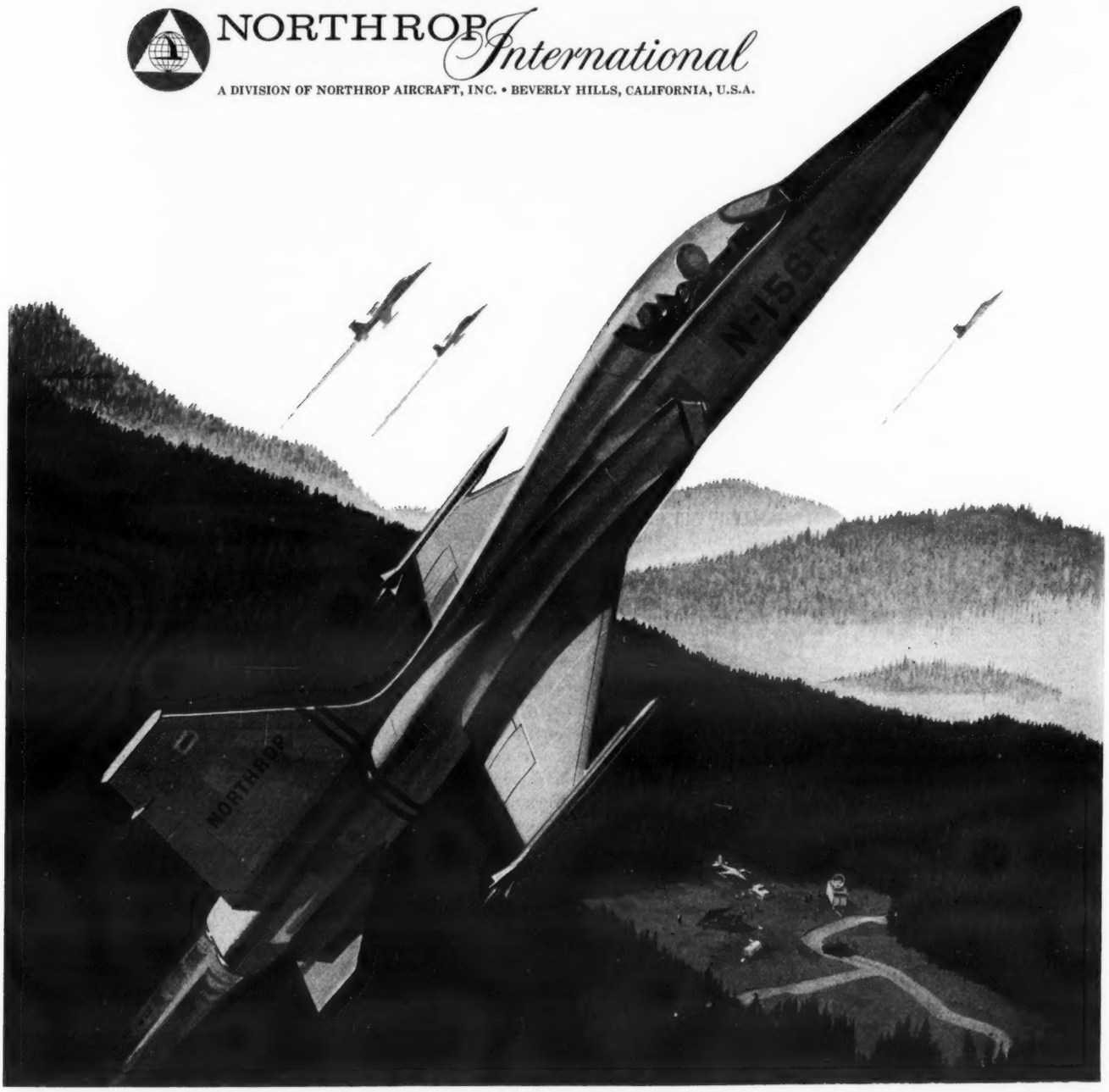

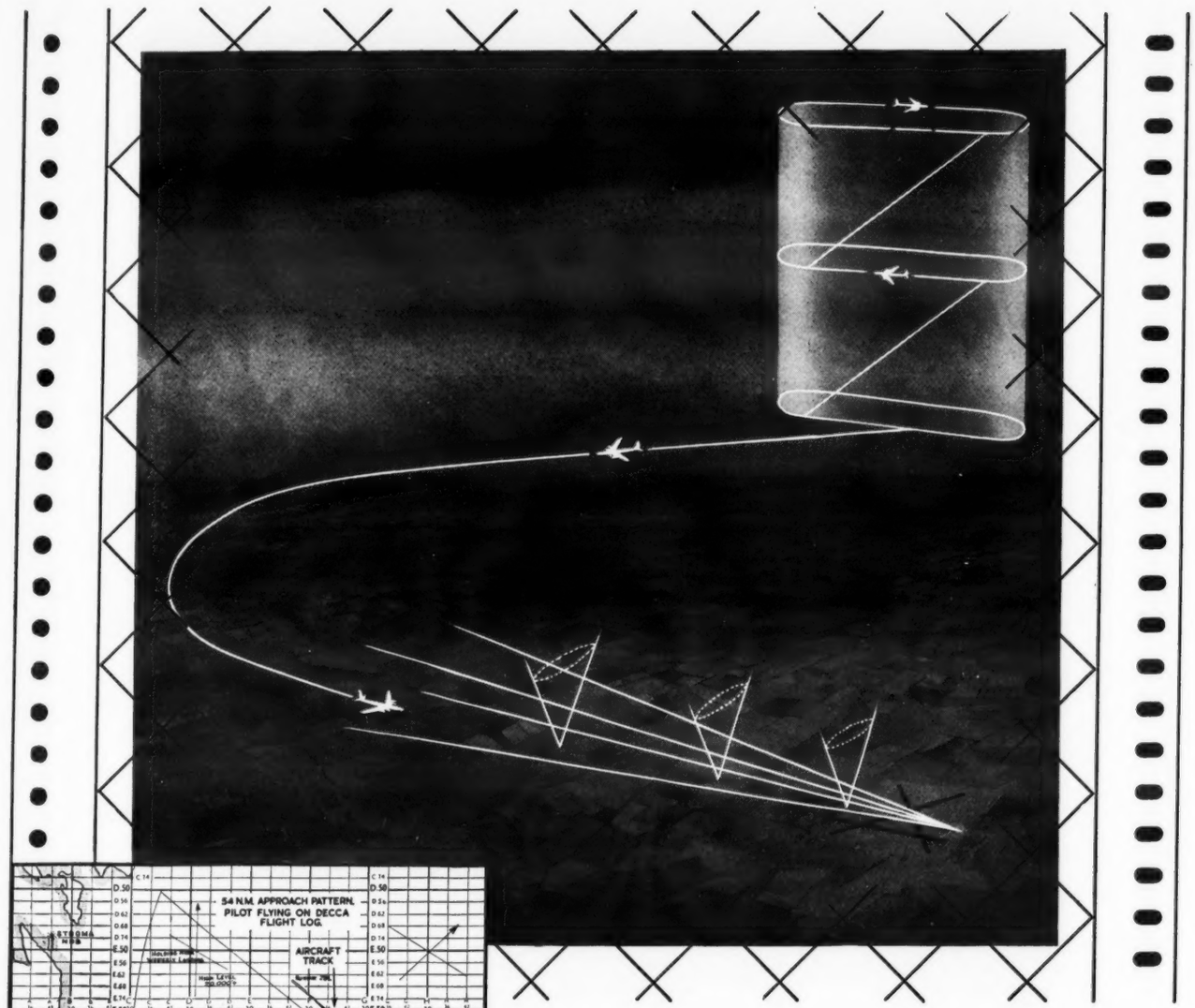

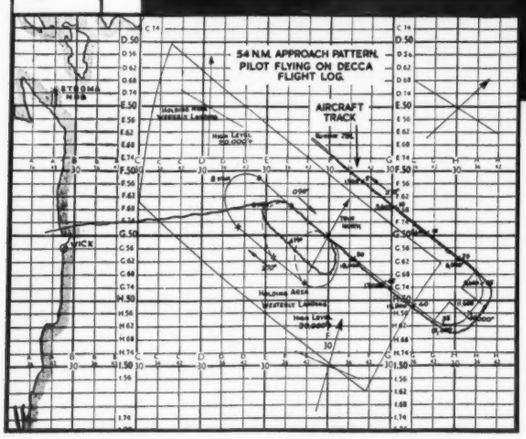

In the trials, held off the Orkneys, the holding area and runway were simulated exactly as for London Airport. In the above chart, used during the trials, the holding area with 4, 6 and 8 minute orbits is clearly shown together with the required track to the runway also clearly marked with altitude checks down to the threshold. With the Flight Log the pilot was able to navigate precisely at every stage of the flight, greatly simplifying the entire holding and approach procedure.

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No other aid is either suitable or accurate enough for holding at altitude within a defined area. With Decca, such areas can be designated independently of ground facilities and flown exactly regardless of drift. Exhaustive tests showed that, with the Flight Log, pilots were able to leave a holding area with a very high degree of precision, track can be maintained precisely during the descent from the holding area to touch down, giving the pilot a continuous check of altitude against distance from touch down.

Knowing exactly where he is at all times by reference to his pictorial display, the pilot has an independent check on radar control, and being able to navigate himself accurately in the terminal area his R/T communication with such control is greatly reduced. The safety of all aircraft is increased by the consequent lightening of the load on the Radar controller. Improved accuracy in time and position keeping, results in the reduction of delays enabling the maximum landing rate to be achieved.

INTERAVIA

Deadline Notes

No. 11, 1958

● **Pan American World Airways** opened regular Boeing 707 jet services between New York and Paris on October 26th. Aboard the Jet Clipper "America" on its inaugural flight were 111 passengers. Shortly before the first scheduled Boeing 707 flight left New York, PAA announced that it had abandoned plans to bring the jet flights into Rome-Ciampino because the Italian Government had imposed a surcharge over the present IATA tariffs. A statement by the company said the matter would have to be resolved through negotiations between the U.S. and Italian governments, but that meanwhile PAA had no choice but to terminate its jet services, originally destined to Rome, at Paris, and to offer its passengers immediate connections with DC-6 *Clippers*.

● **The Alitalia management** is apparently now showing an interest in medium-range jet transports. The Boeing 720, the *Comet 4*, the Convair 600/880 and the de Havilland 121 are all said to be under consideration. The *Caravelle* could not, however, be considered until Alitalia's ten *Viscounts* are withdrawn from service. In any case, the *Caravelle* is said not to figure in the 55,000,000,000 lire credit granted by the Istituto per la Ricostruzione Industriale to cover the period up to 1962. Nevertheless, Alitalia is studying the possibility of getting rid of all its piston-engine and turboprop aircraft and of concentrating on jet aircraft at the earliest possible date.

● **A general meeting of shareholders of Austrian Airlines** is to be held in Vienna during the first week of November to vote on a proposal to increase the company's share capital from 60,000,000 to 200,000,000 Austrian shillings. A decision is to be made shortly regarding AUA's equipment policy.

● **KLM Royal Dutch Airlines** inaugurated a new Amsterdam-Anchorage-Tokyo service on November 1st. The service, which continues on to Biak in Dutch New Guinea, is flown twice weekly. Douglas DC-7C aircraft are used, leaving Amsterdam on Wednesdays and Saturdays. According to *Interavia's* Stockholm correspondent, KLM has been granted permission by the Swedish authorities to make technical landings at Lulea-Kalix Airport and to fly over certain areas previously out of bounds for aircraft. Travelling time between Amsterdam and Tokyo along the new route will be about 32 hours, compared with 48 hours along the old route via Karachi and Bangkok (which will be maintained).

● **British European Airways** will operate, from December 15th, 1958 to March 28th, 1959, twice weekly *Viscount* services between London and Treviso, where bus connections will be provided for Venice and the Dolomites. The flights will be made on Wednesdays and Saturdays. An agreement concluded with the Italian hotelkeepers organization will enable British tourists to stay in Italy at reduced rates from Wednesday to Saturday or from Saturday to Wednesday. Since BEA has also agreed to offer special low-price fares, the scheme will be particularly attractive to people of modest means.

● **Aerlinte Eireann** inaugurated a second transatlantic service on October 8th. The new route links Dublin with New York via Shannon and Boston and is being flown twice a week. The company opened its first transatlantic service in April of this year, operating three flights per week between New York and Shannon and Dublin. During the peak summer months there were daily flights in each direction. Throughout the winter there will be three flights per week to New York with two flights each week into Boston.

● **American Airlines** has announced that daily Boeing 707 jet services between New York and Los Angeles will be inaugurated on January 11th, 1959. Flights between New York and San Francisco through Chicago will begin on January 25th. By mid-summer, the airline will operate 707 services to Dallas, Boston, Baltimore and Washington D.C. (the latter two to be served through Baltimore's Friendship Airport). American also plans a service starting early in 1959 with the Lockheed *Electra* over its short and medium-haul routes. In all, the airline has 110 turbine airliners on order including 25 long-range 707s, 25 medium-range 707s, 25 Convair 600s and 35 Lockheed *Electras*.

● **The Lockheed F-104 Starfighter** (General Electric J79 with afterburner) seems likely to be chosen as standard interceptor for the German Air Force. According to an official report from Bonn, the Federal Defence Ministry recommends the purchase of six to ten F-104s and licence production of another 300 *Starfighters* by the German aircraft industry. The Bundestag Defence Committee, which meets on November 5th, will be asked to approve the Ministry's decision. If approved, delivery of the *Starfighters* to the German Air Force will be made in 1961/1962. Other reports from Bonn state that 150 complete *Starfighters* would be bought from Lockheed, and a similar number be produced under licence. Licence production of the F-104 will probably be entrusted to Flugzeugunion Süd (Heinkel, Messerschmitt, Junkers), so that the reactivated south German aircraft firms will be assured of work for some time.

At the request of the Defence Ministry, Karl Frydag, President of the German Aircraft Manufacturers Association, has taken on the task of acting as liaison between the Ministry and the Industry and of ensuring the rational distribution of all orders.

● **Weser Flugzeugbau G.m.b.H.,** Bremen, which is associated with Hamburger Flugzeugbau and Siebel-Werke ATG in Flugzeugbau Nord G.m.b.H. and is owned by the Krupp concern, has increased its share capital from DM 4,000,000 to DM 7,000,000. The new issue has been taken up by United Aircraft Corporation, East Hartford, which has thus acquired a 43 percent holding in Weser Flugzeugbau G.m.b.H. A first step towards close cooperation to follow the financial deal will be the production by the German company of Sikorsky Aircraft Division helicopters. American interest in Weser Flugzeugbau dates back to April 1953. Since that time, Weser Flugzeugbau has acquired a licence from Vertol Aircraft Corporation for the production and sale of H-21 helicopters. This is the first time since the war that a substantial American investment has been made in the German aircraft industry. The first move towards the licence production of Sikorsky helicopters in the German Federal Republic was made in the early summer of 1955 when Sikorsky Aircraft Division, or rather United Aircraft Corporation, concluded an agreement to this effect with the Henschel company, Kassel. The agreement was cancelled, however, when Henschel got into difficulties, the financial side of which has since been overcome.

● **Renault and Alfa Romeo** recently concluded a production and sales agreement covering automobiles and diesel engines. The agreement will come into force on January 1st, 1959. The accord provides, *inter alia*, for the joint production by the two companies of diesel engines at Alfa Romeo's Pomigliano d'Arco plant. Although it is envisaged to base the resumption of activities at Pomigliano d'Arco on diesel engine production, in the opinion of *Interavia's* Rome Correspondent, this does not necessarily mean that components for the Rolls-Royce *Dart* and *Conway* turbine engines will not be manufactured there in addition. This would be possible if Rolls-Royce placed orders with Alfa Romeo to cover at least part of the expenses incurred by IRI in getting production of these items under way.

● **Marconi's Wireless Telegraph Company Ltd.** and Jugoimport, a Yugoslav import agency, have reached an agreement for the manufacture in Yugoslavia of Marconi sub-miniature Automatic Direction Finders, Type AD722. Marconi's will supply parts for assembly and an initial order for the sub-assemblies has been placed with the company, together with a complementary order for completed units. Marconi's are also to give technical assistance with the manufacture of the ADF's in Yugoslavia.

● **Pye Ltd.** has been most successful in selling its equipment to Iron Curtain countries. Pye ILS has been installed at Moscow and Prague Airport, is in process of installation at Budapest, and is under consideration for Warsaw, Schoenefeld and Kiev.

● **Canadair Ltd.,** Montreal, has just completed the last production F-86 *Sabre* jet fighter. Canadair produced its first *Sabre* in 1950. Including exports of aircraft and parts, *Sabre* sales from Canadair were just short of $560,000,000 and went to nine nations. The first 350 Canadian-built *Sabres* were virtually identical to the aircraft built by North American Aviation Inc. and were powered by General Electric J47 jet engines. The next 1,150 produced were fitted with Canadian-designed *Orenda* engines.

● **United Aircraft Corporation** has announced the formation of United Research Corporation which will support research in advanced propellants for missile and space craft in cooperation with the Stanford Research Institute. Quantity production of any propellants resulting from the efforts of this research organization, however, will probably be licensed to an established propellant manufacturer. Lieutenant General Donald L. Putt, formerly Deputy Chief of Staff, Development, USAF, has been elected President of the new corporation. He will be advised by a scientific directorate of internationally known scientists including Dr. Isidor I. Rabi of Columbia University, winner in 1944 of the Nobel Prize in Physics and an outstanding authority on nuclear physics ; Dr. C. Richard Soderberg, Dean of Engineering at Massachusetts Institute of Technology ; Dr. H. Guyford Stever, assistant Dean of Engineering at M.I.T. and former Chief Scientists of the USAF ; Dr. Bernard Lewis, Combustions and Explosives Research, Inc., Pittsburgh, formerly director of research and development of Ordnance Corps, U.S. Army ; and S. Allan Kline, President of Sierra Metals Corporation, a subsidiary of American-Marietta Company. The officers of United Research Corporation will include as Vice President, Wright A. Parkins, United's Vice President and General Manager of its Missiles & Space Systems Division ; Donald H. Culver, Charles H. Chatfield and George W. Weeks. The Board of Directors : William P. Gwinn, General Putt, Wright A. Parkins, William R. Robbins, Perry W. Pratt and John G. Lee.

● **Aerojet-General Corporation,** Azusa, California, and the Bristol Aeroplane Company, Ltd., Bristol, have agreed to form a new joint company to be known as Bristol-Aerojet, Ltd. ; the new company's plant will be located in England, and will be devoted to the development, manufacture, casting and testing of solid rocket motors, including propellant formulation. Bristol-Aerojet, Ltd. will have the exclusive right to exploit Aerojet solid-propellant rocket products within the field of the agreement in the United Kingdom and the British Commonwealth, and possibly a number of countries on the European Continent. The directors, nominated equally by each of the parent companies, will be as follows : nominated by Bristol : Sir W. Reginald Verdon Smith, Chairman of the Bristol Aeroplane Co. Ltd. as Chairman ; Rear Admiral Sir Matthew Slattery, C.B., Chairman of Bristol Aircraft Ltd. and Short Brothers and Harland Ltd. ; Walter Strachan, General Manager of Bristol Aircraft Ltd. (Weston Division). Nominated by Aerojet-General : Dan A. Kimball, President of Aerojet-General Corporation ; Sir Alwyn Crow, C.B.E., Aerojet's British representative ; W. E. Zisch, Vice President and General Manager of Aerojet-General Corporation.

● **B.F. Goodrich Company** has announced the establishment of new subsidiaries in Brazil, Australia and Iran. B.F. Goodrich do Brasil will be located at Campinhas, in the State of São Paulo, and will specialize in the manufacture of tyres and tubes as well as other rubber and plastic products for the automobile industry. B.F. Goodrich Australia Ltd. will engage in the production of similar items and will have its premises near Melbourne. B.F. Goodrich Iran, Inc. will commence production of tyres and tubes in July 1960.

● **Kaman Aircraft Corp.** has been awarded a $10,000,000 "follow-on" contract for 54 of its H-43B turbine powered helicopters by the U.S. Air Force. The company is already producing H-43 helicopters for the Air Force under a previous contract also amounting to $10,000,000. The H-43B is powered by a Lycoming T-53, 825-h.p. engine. The carrying capacity of the H-43B is increased from five, including pilot and co-pilot, to eight compared with the H-43A. The contract calls for spare parts, ground handling equipment, handbooks and technical data as well as aircraft.

● **The Martin Company** has installed a new launch stand on the *Vanguard* pad at Cape Canaveral, Florida, which will enable future satellite launching rockets to be fired in winds up to 38 m.p.h. velocity. Although five *Vanguard* test rockets and the first two *Vanguard* satellite launch rockets successfully cleared the former launch stand after first stage ignition, the Navy felt that a new stand was needed to provide a greater choice of launching days for future satellite vehicles.

● **The first Nike Ajax anti-aircraft missiles** destined for the Italian Air Force were formally handed over to General Giuseppe Mancinelli, Chief of the Italian Defence Staff, at a ceremony at Fort Bliss, Texas, on October 21st. 680 Italian servicemen are now undergoing *Nike* training at Fort Bliss.

● **The Astronics Division of Lear, Inc.,** Santa Monica, California, has established a new engineering flight test centre at Ontario California International Airport. Principal activity of the new centre will be the testing of Lear autopilots and related equipment in advanced military jet aircraft. It will be devoted primarily to the support of experimental and development engineering work in the fields of flight stabilization and control.

● **The Austrian Air Force** has decided to place an order for fourteen Fiat G.91 aircraft. The formal signing of the contract will take place in the very near future.

Workshop Briefs

• The *Lobber, a highly-classified Convair missile* designed to deliver supplies to front-line troops, reportedly is approx. 9 ft. long, 10 in. in diameter, and capable of a range from 6 to 8 miles. Reports indicate that the *Lobber* carries up to 30 individual meals or equivalent weight of ammunition or medical supplies.

• *Exports of Czechoslovak sports and touring aircraft* (including aircraft for taxi services) have shown the following increases since 1955 : Taking the 1955 figure as 100, 1956 results were 257 and 1957, 446. Czech-produced aircraft are today in operation in more than 45 countries, including Argentina, Brazil, Canada, the Belgian Congo, the United Arab Republic, Australia, India, France, Italy, China and the USSR.

• The period between overhauls for the version of the *Pratt & Whitney J57 jet* engine fitted in the Boeing B-52 long-range bomber has recently been increased from 1,000 to 1,400 hours. The J57 version used in the KC-135 has also been authorized for a between-overhauls life of 1,400 hours (as against 800 hours hitherto).

• *The Morane-Saulnier MS.1500 Epervier,* equipped with a Turboméca *Bastan* turboprop, is now undergoing flight testing.

• The *Piasecki VZ-8P Flying Jeep,* developed and built under a U. S. Army contract, recently commenced flight testing. It is intended to put a four-seat civil version of the VZ-8P, known as *Sky Car,* on the market.

• Professors and students at the Aeronautical Institute in Peking have developed and built a small twin-engine transport, designated *Peking No. 1.* It is designed for eight passengers and a 2-men crew, and is now undergoing flight testing. All-metal low-wing monoplane with retractable nose wheel undercarriage ; max. speed 162 knots ; max. range more than 540 n.m.

• The *Antonov An-16* for 130 passengers has been mentioned for the first time. Apparently this is a development of the An-10 *Ukraina* turbine transport.

• *The A. V. Roe Type 748* is the design of a possible DC-3 replacement. It is fitted with twin Rolls-Royce *Darts.*

• The *McDonnell Model 119 jet training and communications aircraft* will be ready for flight testing at the turn of the year.

• The new *Walter Minor 8c* aircraft engine in the version planned for the *Meta Sokol* sports and touring aircraft is now on the market. The Walter *Minor 8c* is an air-cooled 4-cylinder in-line engine with low-pressure fuel injection system ; compressor ; electric starter. Take-off power is 140 h.p. with an installed weight of 224 lb.

• *Longren Aircraft Company* has developed the Convair L-13 communications aircraft into a new multi-purpose model, the *Centaur,* for light freight operations, survey work, ambulance services, etc. Power is supplied by a 300-h.p. Lycoming R-600-13 engine. A first production model is to be ready early in 1959.

• The stainless steel and ceramic *research aircraft* under construction by *Bristol* is now revealed as the T-188. It is suitable for speeds between Mach 2.5 and 3.0.

• *The first F-104C Starfighter* has been delivered to the USAF. Holder of the world's speed record (1,404 m.p.h.) and altitude mark (91,243 ft.), the aircraft has in-flight refuelling provisions wich give it globe-circling range for its assignments with TAC's Composite Air Strike Forces. It is equipped with a General Electric T-171 six-barrelled 20-X *Vulcan* cannon, firing 6,000 rounds per minute, and can carry a variety of external loads, including atomic bombs.

Note : *Commenting on the passage concerning the Las Vegas collision in the article entitled "Mid-Air Collision" by Professor Dr. S.J. Gerathewohl, which appeared in the August 1958 issue, the USAF School of Aviation Medicine points out that since military control towers do not receive any information from CAA on other than inbound IFR traffic for their airfields, or conflicting IFR traffic that may delay IFR departures, the personnel in the tower had no knowledge of the airliner. At the time of the accident, the CAA had not been either equipped or staffed or required to provide flight following for other than IFR traffic. Meanwhile, however, a new Federal Aviation Agency, whose tasks include the coordination of military and civil aircraft movements, has now been created.*

BRISTOL RAMJETS POWER

BLOODHOUND DEFENCE SYSTEM

A ramjet-powered Bloodhound missile in supersonic flight

Close-up of ramjet air-intake during flight

—now ordered by Sweden

Choice by European neutral confirms operational effectiveness of Bristol/Ferranti's surface-to-air guided missile system and its ramjet engines

Adoption of the Bloodhound—already approaching full operational status with the RAF as mainstay of Britain's air defence—was made by a Swedish assessment team after exhaustive evaluation of the merits of surface-to-air guided missile systems available throughout the world.

Bristol ramjets—ensuring long range, flexibility, simplicity of handling—play a large part in making Bloodhound the most effective defence system of its kind in the world—*now and for many years to come.*

Bristol Siddeley

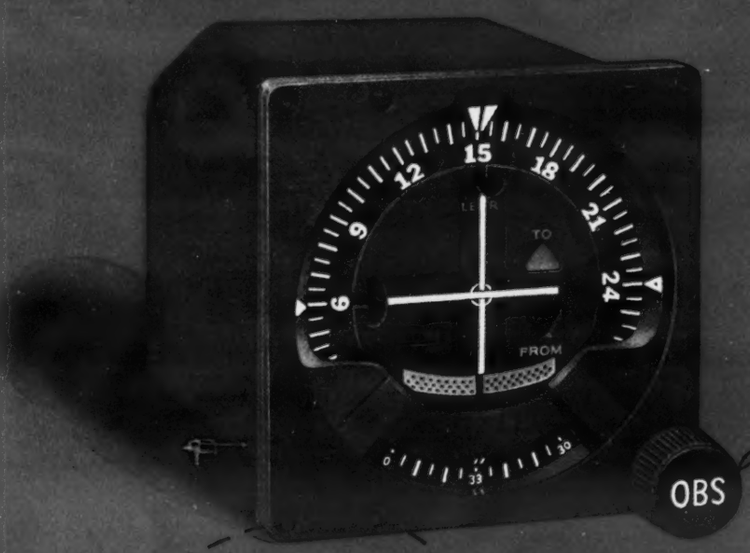
ENGINES LIMITED

combined

VOR + ILS

IN A SINGLE INDICATOR

LEAR MODEL *4087*



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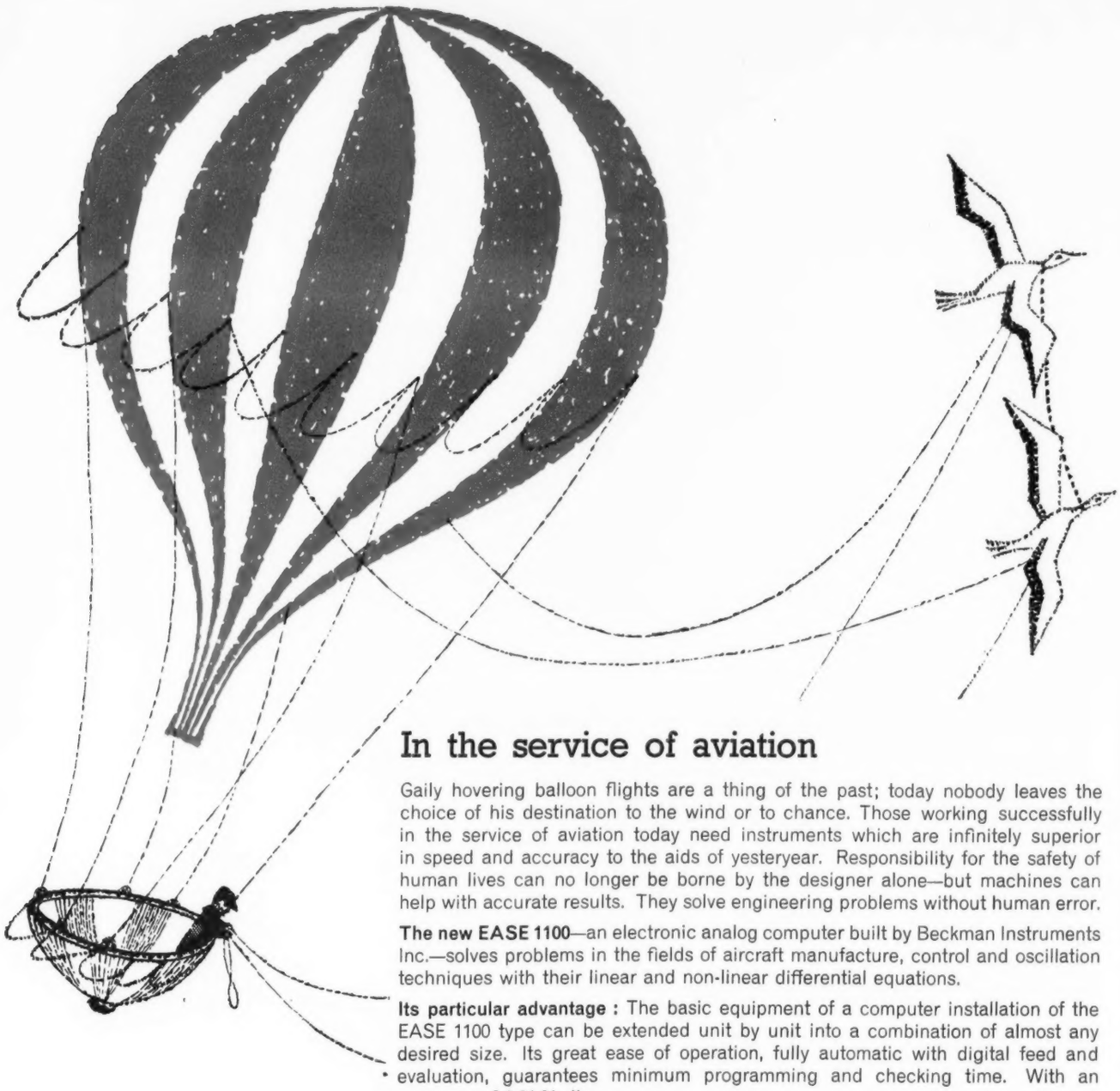
SINCE 1930 *the finest* FLIGHT EQUIPMENT

LC-65

3171 S. Bundy Dr., Dept. SM SANTA MONICA, CALIFORNIA **LEAR** LEARCAL DIVISION



In the service of aviation

Gaily hovering balloon flights are a thing of the past; today nobody leaves the choice of his destination to the wind or to chance. Those working successfully in the service of aviation today need instruments which are infinitely superior in speed and accuracy to the aids of yesteryear. Responsibility for the safety of human lives can no longer be borne by the designer alone—but machines can help with accurate results. They solve engineering problems without human error.

The new EASE 1100—an electronic analog computer built by Beckman Instruments Inc.—solves problems in the fields of aircraft manufacture, control and oscillation techniques with their linear and non-linear differential equations.

Its particular advantage : The basic equipment of a computer installation of the EASE 1100 type can be extended unit by unit into a combination of almost any desired size. Its great ease of operation, fully automatic with digital feed and evaluation, guarantees minimum programming and checking time. With an accuracy of 0.01 %, the

EASE 1100 is a prince among electronic analog computers.

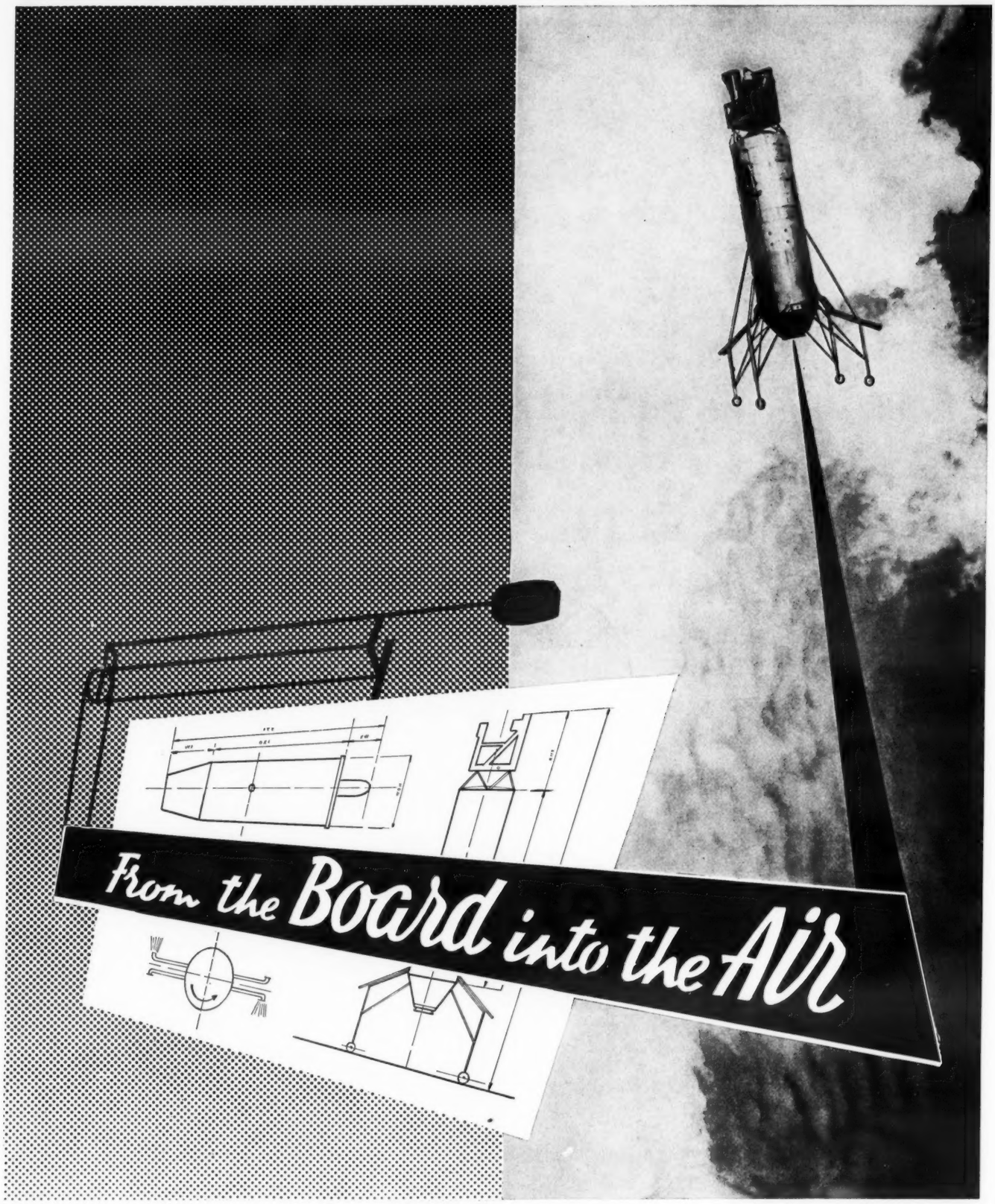
Beckman®

Our analog computer center in Munich is at your disposal for the solution of problems concerning oscillation and stability techniques or for the simulation of technical and physical processes and control systems.
Please write for further details under « R 20 ».

Beckman has supplied analog computers to many leading industrial companies, including :

G. M. Allison Division, Indianapolis, Indiana,
Boeing Airplane Company, Seattle, Washington,
Chrysler Missile Corporation, Warren, Michigan,
Brown, Boveri & Cie., Baden, Switzerland,
Federal Ministry for Atomic Affairs, Frankfurt/Main

Beckman Instruments GmbH
Munich 45, Frankfurter Ring 115



SOCIÉTÉ NATIONALE
D'ÉTUDE ET DE CONSTRUCTION DE MOTEURS D'AVIATION
150, Boulevard Haussmann - PARIS-VIII

MOSQUITO

Wire-controlled anti-tank rocket
CONTRAVES/OERLIKON
for one-man operation

Gunner in firing position with control box and two MOSQUITOS

Arming of the hollow charge warhead during flight by the gunner

Training rocket recoverable after target flight by means of parachute

The technical data characterize the MOSQUITO as a rocket of outstanding performance

Recovery of a training rocket

CONTRAVES A.G.
Zürich-Seebach

Oerlikon Machine Tool Works,
Bührle & Co.
Zürich-Oerlikon

NOVEMBER 1958

A special report on the General Electric CJ-805

already scheduled for service with

AMERICAN AIRLINES
DELTA AIRLINES
SAS
SWISSAIR
TRANS WORLD AIRLINES

CJ-805

CJ-805 RECEIVES OFFICIAL CAA CERTIFICATION

On Sept. 9, General Electric's CJ-805 received its CAA type certification . . . important milestone in its intensive test program. General Electric's goal in this program: to provide airlines with a reliable, dependable, high performance jet engine for commercial operation.

Here are highlights of the CJ-805 test program:

Endurance Tests Prove a Mature Engine

CJ-805 factory tests are proving the reliability of all engine parts, components, and accessories. Progress to date: first endurance engine has now logged almost 2000 hours; second engine more than 1000 hours on kerosene. A total of 9 engines are now engaged in factory and flight testing.

The endurance engines are run to simulated airline schedules, approximating conditions of successive 1-hour, 1½-hour, and 2-hour commercial flights. Conditions include taxi, take-off, climb, cruise, descent, reverse thrust and taxi regimes—a total of over 600 engine starts and stops for every 1000-hour period.

No parts change during initial flight tests

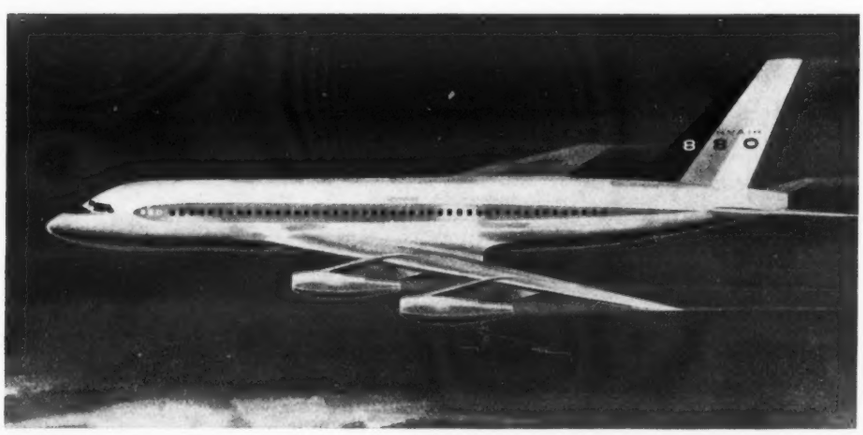
During initial flight tests, a prototype CJ-805 engine logged a total of 150 hours in 25 working days without a parts change or engine adjustment. Included in the flight tests: throttle bursts and chops at altitudes up to 45,000 feet, plus air starts at various altitudes. Flight testing of the production CJ-805 is now underway.

160% overspeed ; 75° overtemperature

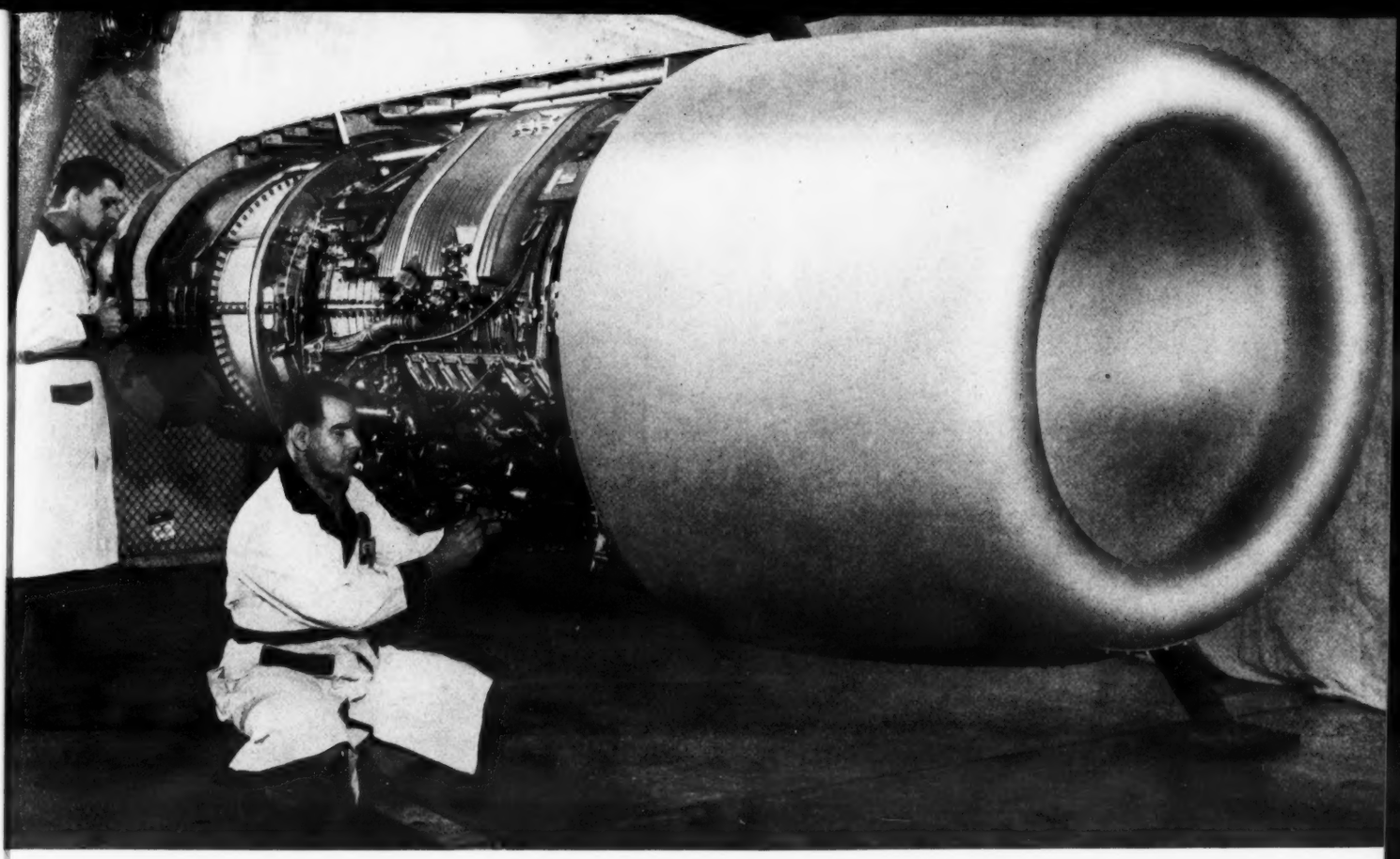
CJ-805 components are being tested above normal requirements. The compressor rotor, for example, has been tested to 135% speed; the turbine rotor to 160% speed and 75° overtemperature.

Hailstorm tests demonstrate CJ-806 ruggedness and durability

The CJ-805 has been tested under severe hailstorm conditions. One and one-quarter inch iceballs were fired into a running CJ-805 at iceball speeds from zero to 637 miles per hour with no effect to engine operation. Power settings included maximum rpm. With two-inch iceballs, the engine took hits up to 378 mph



Swissair has announced the purchase of 5 Convair 880's, powered by General Electric CJ-805 turbojet engines. Through a lease arrangement, 2 of these aircraft will be operated by Scandinavian Airlines System.



without damage. These tests were conducted at speeds 28% in excess of requirements.

CJ-805 reverser and suppressor tests successful

A CJ-805, mounted in a Convair 880 wing pod, is testing G. E.'s Reverser Model TR-22 at General Electric's outdoor test facility. A prototype reverser has already completed 500 reversals.

Acoustical and performance tests of the shrouded daisy ejector suppressor are proving successful. The ejector daisy provides excellent nozzle efficiency at a wide range of power settings, promising minimum loss in altitude performance.

The new aft-fan CJ-805, scheduled to power American Airlines' Convair 600's, has also been run outdoors for sound level measurements. Results so far indicate the aft-fan principle is helpful in reducing engine noise.

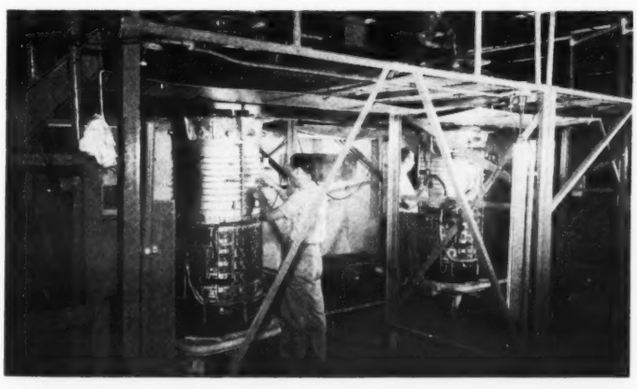
What these CJ-805 tests mean to airlines

When the CJ-805's enter service, they will join more than 30,000 other G-E turbojets built for the Armed Services. These engines have already—today—logged more than 22,000,000 flight hours and 10 billion flight miles.

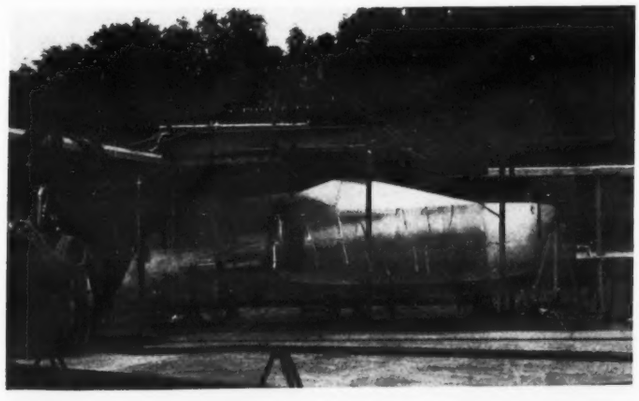
General Electric's CJ-805 test program is one more assurance that *airlines*, like the Armed Services, will get ruggedness . . . reliability . . . dependability . . . and economy when the new CJ-805 begins flying the nation's commercial airways in 1960. *General Electric Co., Cincinnati 15, Ohio.*

Progress Is Our Most Important Product

GENERAL ELECTRIC



First production model of CJ-805 was delivered to Convair in September. Military version of the CJ-805 (the J79) recently powered the Lockheed F-104 to new world altitude and speed records.



CJ-805 sound suppressor and thrust reverser tests are being conducted at G.E.'s Peebles, Ohio, test facility.

13 VITAL AIR DEFENSE MISSIONS, 2 PLANES, ONE COMP

The Lockheed F-104 *Starfighter* holds two major world's records: Speed, 1404 miles-per-hour; Altitude, 91,249 feet. This famous "missile with a man in it", which underwent two years of rigorous flight testing before entering service with the U. S. Air Force, was designed to give it a multi-mission capability unequalled by any other plane of its size and type. All six of these vital military missions can be performed by the Lockheed F-104 *Starfighter* with outstanding excellence:

1. Identification
2. Interception
3. Tactical bombing
4. Reconnaissance
5. Attrition
6. Air superiority

COMPANY . . . LOCKHEED

During 22 months of world-wide U. S. Air Force service, the Lockheed C-130 *Hercules* has dramatically demonstrated its unmatched capabilities for tactical and strategic deployment missions. Powered by 4 mighty Allison propjet engines, the *Hercules* can land on or take off from improvised strips, deep snow, or desert sand. It climbs 2450 feet-per-minute, attains 35,000-foot altitudes, cruises at 305 knots, and has a range capability of 3500 nautical miles. No other plane now flying can perform all 7 of these missions as well as the Lockheed C-130:

1. Strategic/tactical airlift
2. Missile carrier
3. Paratroop transport
4. Cargo paradrop
5. Aeromedical evacuation
6. Photo mapping/charting
7. In-flight refueling tanker-plane

To insure the optimum performance and utilization of all Lockheed planes—at the lowest cost to the purchaser—the Lockheed Aircraft Corporation maintains a world-wide service and supply organisation without an equal in the aircraft industry. Lockheed field representatives with broad technical knowledge are always available to instruct and assist maintenance crews. Lockheed Aircraft Service provides spare parts and major overhaul facilities at five strategically located points throughout the world.

Lockheed Aircraft Corporation

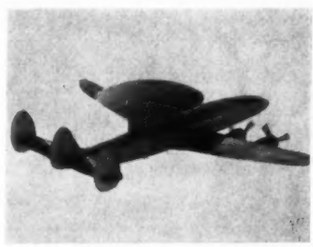
Burbank, Palmdale, Palo Alto, Sunnyvale, Santa Cruz and Van Nuys (California) . . . Marietta and Dawsonville (Georgia) . . . Holloman Test Center (New Mexico) . . . Cape Canaveral (Florida).

Lockheed Aircraft Service

Ontario and Oakland (California) . . . Jamaica (New York) . . . Honolulu (Hawaii) . . . Gifu (Japan).

Manufacturing: Lockheed's facilities, if gathered together in one place, would cover a ground area greater than all of world-famous Manhattan Island.

Experience: The latest example of Lockheed's quarter-century of experience in the design and production of high-performance aircraft is the *Jetstar*—a 10-passenger multi-mission utility jet trainer/transport.



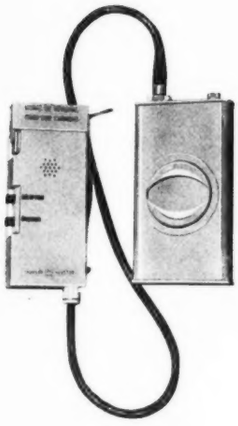
Electronics: Airborne Early-Warning radar patrol planes are just one example of Lockheed leadership in airborne electronics. Advanced antenna development is another.

Support: Lockheed Field Service experts give world-wide training to both military and civilian personnel in maintenance and repair of all Lockheed aircraft.

LOCKHEED *means leadership*

DISTRESS MARKER

(with tubes or transistors)



The TH. C. 985 (version with tubes) and TH. C. 986 (transistorized version) sub-miniature transmitter-receiver consists of two very light units, both simple, reliable and automatic in operation. It enables a pilot in distress to signal his position to a search aircraft equipped with a homing receiver (ARC 34 or 1,750-channel UHF) or a radio compass such as the ARA 25. Range is 30 miles for R/T and 60 to 75 miles for W/T.

The equipment is actuated by pulling a ring, whereupon the antenna extends, and the set automatically begins to transmit a signal on modulated telegraphy (A 2). Subsequent interchange of communications is made by telephony (A 3) on simplex.

Guaranteed waterproof (tested in 13 ft. of water).
TH. C. 985/986 sets can be preset in the 238-248 Mc/s band or, with modifications, in the 119-224 Mc/s band.

- Endurance more than 30 hours.
- Maximum weight: 1 lb.
- Very low consumption with low-power battery.

TH. C. 985/986

THOMSON CFTH HOUSTON

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1134

PLESSEY BRINGS DOWN COST OF RADIO TELEPRINTER OPERATION WITH TYPE 102A SERIES TERMINAL.

Type PVR.102A Fixed Station Diversity Radio Teleprinter Receiving Terminal for H.F.

The low initial cost and relatively simple installation of the Plessey Type 102 Series Terminal makes possible radio teleprinter links where previously they would have been uneconomic. Designed in collaboration with International Aeradio Limited, the equipment is particularly suitable for regional point-to-point communication and meteorological broadcasts at airports, also for press agency and similar work.

Some of its many outstanding features are detailed below.

A comprehensive brochure is available on request.
Ask for Plessey Publication No. 789/1.

FEATURES

Built-in metering arrangements provide for checking, setting-up and monitoring of all important circuit functions. Direct operation of up to three teleprinters; no keying relays are used, thus ensuring maximum reliability and freedom from radio interference. Five separate channels are pre-set and crystal controlled. Provision of crystal trimmers ensures that frequency is exact. Change of channel can be effected by the operation of one knob.

Channel selector switch can be motor driven from the rear thus permitting remote control. A remote channel selection unit is available.

F.S.K. transmissions of differing shifts are catered for by the use of linear discriminator covering 200–850 CPS. Rapid diversity switch action on small signal differential over wide range of inputs. Complete suppression of weaker diversity signal.

Plessey ELECTRONIC AND EQUIPMENT GROUP

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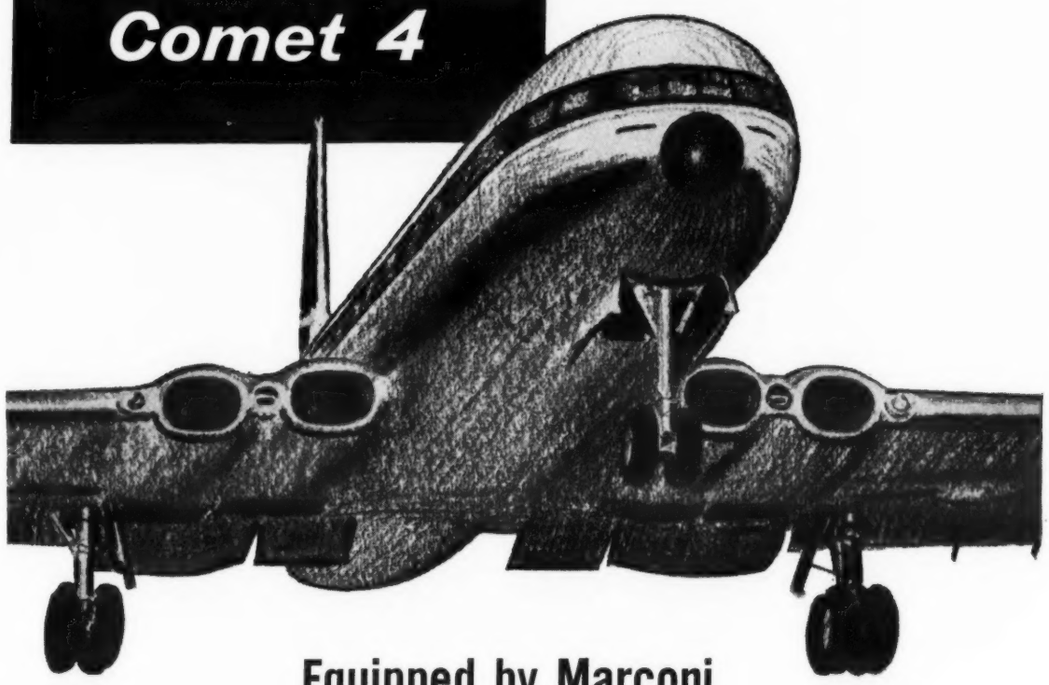
Marconi in the Comet 4



Equipped by Marconi to meet the major radio requirements of a modern airliner

MARCONI

COMPLETE AIRCRAFT AND AIRPORT RADIO SYSTEMS

MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED, CHELMSFORD, ESSEX, ENGLAND

M.2A

NEW SKY QUEEN...

from aviation's royal family

Latest bearer of the DC crest, which has been worn with distinction by three previous generations of Douglas airliners, is the giant jet DC-8.

It must live up to the finest tradition in aviation... that of providing the best combination of speed, comfort, dependability and low operating cost in its time.

All the lessons learned during the building and flying of thousands of DC-3, DC-6 and DC-7 series airliners, plus the most varied jet experience in the industry, have been heavily drawn upon in the design and construction of this great new passenger transport.

It will fulfill its heritage with honor to its maker and profit to the airlines on whose routes it will soon appear.

DOUGLAS

BENDIX—

In today's air-minded world the problem of communication between aircraft and ground installations has multiplied tremendously. In an era of overcrowded airlanes and long flights through all kinds of weather, a pilot's ability to communicate instantly and clearly with informed, trained ground personnel can save a plane, a cargo, a hundred lives.

Bendix—the number one name in aviation communications—has become a synonym for reliability the world over. If you have a communications problem or simply seek additional information, we'd like to tell you about Bendix communications equipment.

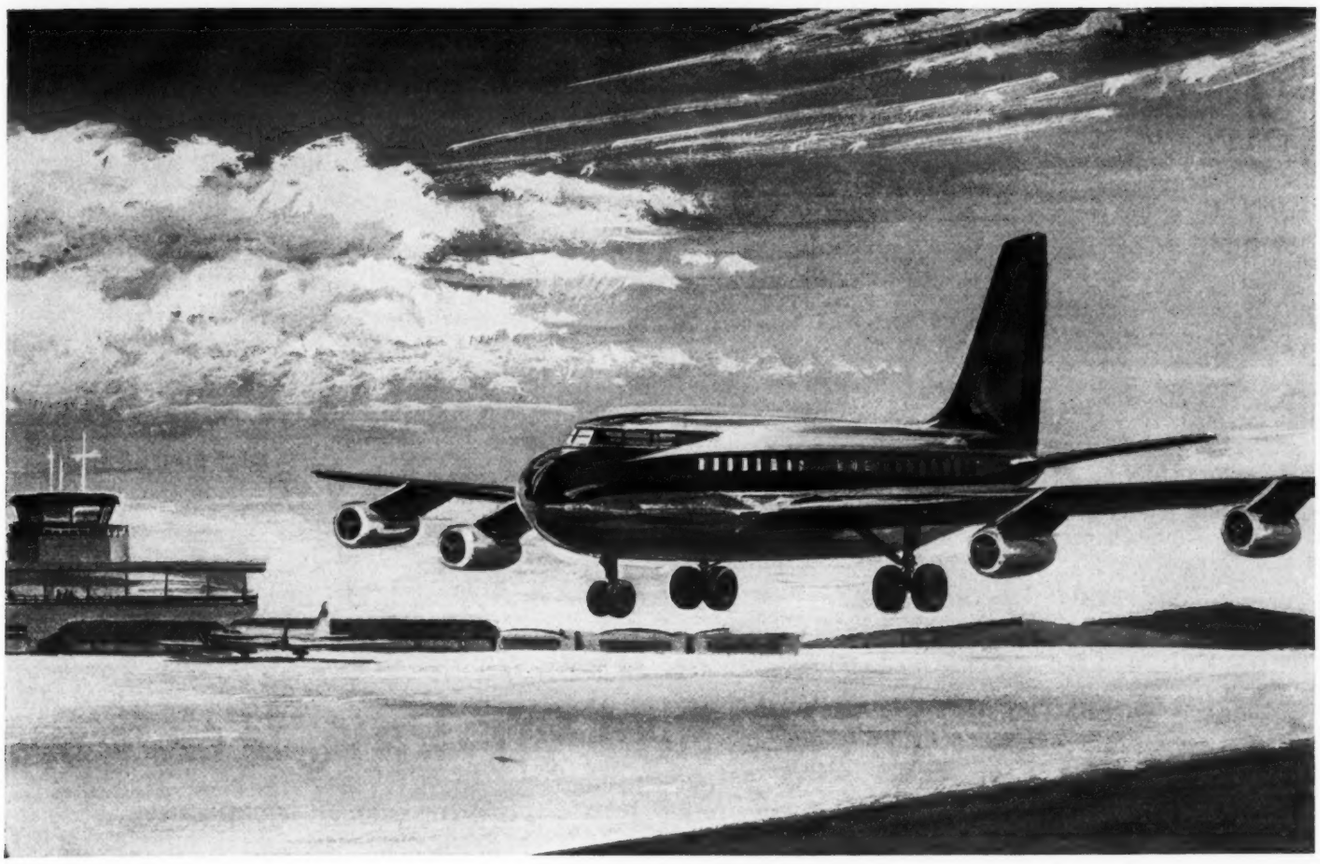
COMMUNICATION

RADAR
RADIO TRANSMITTERS
RADIO RECEIVERS
RADIO NOISE FILTERS
AIRCRAFT INTERPHONE SYSTEMS
AMSPEAKER—PILOT LOUDSPEAKER
RADIO COMMUNICATION SYSTEMS
AUTOMATIC RADIO COMPASS
VHF OMNI-DIRECTIONAL RANGE EQUIPMENT
DISTANCE MEASURING EQUIPMENT
BEACONS
MARKER BEACON RECEIVERS
AIRCRAFT ANTENNAS
VHF TRANSMITTERS AND RECEIVERS
VHF GROUND DIRECTION FINDERS
RADAR ANTENNAS (AIRBORNE AND GROUND)
MICRO-WAVE EQUIPMENT

BRAKES, LININGS AND LANDING GEAR

LANDING GEAR
BRAKE LINING
CERAMETALLIC* LINING FOR BRAKES AND CLUTCHES

go together



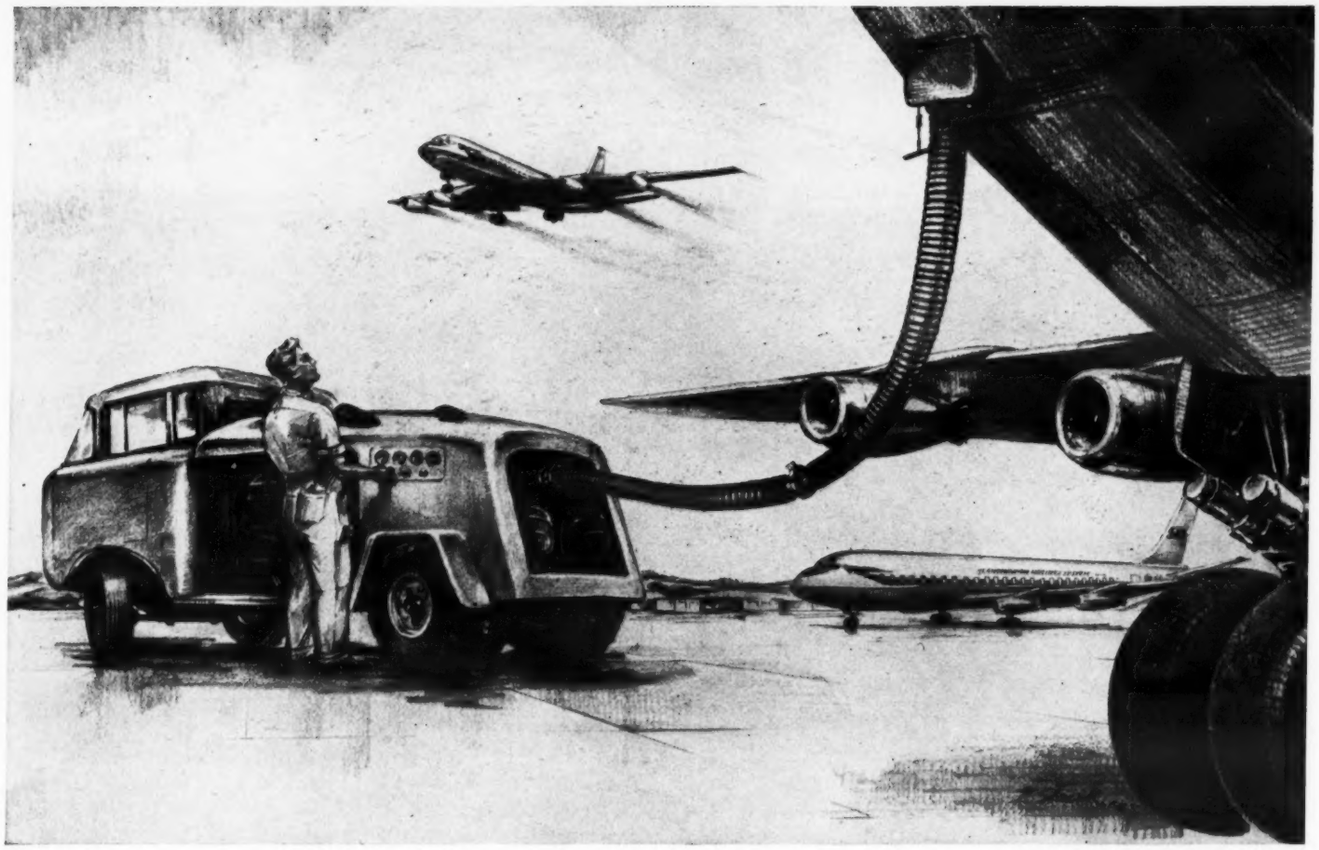
BENDIX—

From the moment a plane touches down until it is airborne again, its safety depends upon the perfect coordination of every element of its landing gear system. It is vital that all components of that system work together with unfailing accuracy and precision. So, common sense suggests that when you think of landing gear you think of Bendix, specialists in complete, integrated landing gear systems. Components designed and engineered to work together are more reliable than any arbitrarily assembled system. When purchasing landing gear, be sure you investigate complete landing gear systems by Bendix. We will give prompt attention to your inquiries.

HYDRAULIC ACTUATING CYLINDERS
POWER BRAKE VALVES
SHOCK-ABSORBING STRUTS
SHOE AND SEGMENTED ROTOR TYPE BRAKES
WHEELS
MASTER CYLINDERS
HYDRAULIC BRAKE CONTROL VALVES

Division of Bendix Aviation Corporation, 205 E. 42nd St., New York 17, N. Y.
U. S. A., Cable "Bendixint", N. Y.

*REGISTERED TRADEMARK BENDIX AVIATION CORPORATION



SAS chose the 'Air Partner'

Scandinavian Airlines System will use 10 Atlas Copco 'Air Partner' compressors to service their fleet of DC-8 jet airliners

STARTING · AIR CONDITIONING · DE-ICING

The Air Partner is a surge-free rotary screw compressor of the Lysholm type designed for starting, air conditioning and de-icing all jet and turbo-prop airliners having air turbine starters.

A SUCCESSFUL COMBINATION

Atlas Copco, the world's largest organisation devoted exclusively to the manufacture of compressed air equipment, combined aeronautical expertise with compressor know-how to produce this multi-purpose unit.

STARTING

The Air Partner delivers a continuous flow of warm, oil-free air to turn the engine over constantly thus eliminating mis-starts.

AIR CONDITIONING

The Air Partner becomes an air conditioning unit by merely flicking the appropriate switches and pressing a button, a matter of seconds.

DE-ICING

A special mouthpiece attached to the air hose enables the wings and fuselage to be 'sprayed' with warm air. Removal of ice and sleet from windshields, wing leading edges, and air intake lips is achieved by using the ordinary de-icing outlets of the aircraft.

SIMPLE MAINTENANCE

The Air Partner has no wearing parts. It consists of two screw rotors which intermesh but never touch one another or the casing. 10,000 hours is the normal period between overalls for screw compressors of this type.

Maintenance operations can be carried out by airline personnel anywhere in the world or through the Atlas Copco sales and service organisation established in 90 countries.

TWO MODELS

Air Partner M-3 consists of two identical units, each including a compressor connected to a standard petrol or diesel engine, for starting, air conditioning, de-icing and checking auxiliary systems.

Air partner M-2 consists of one rotary screw compressor connected to a standard petrol or diesel engine for starting and limited air conditioning.

THE *Atlas Copco* AIR PARTNER

A contribution to the jet age of air travel

Contact your local Atlas Copco company or agent or write to Atlas Copco AB, Stockholm 1, Sweden

C34

Must Sell... 2,000 Piston-Engine Aircraft

Allan A. Barrie probably does not see a great deal of his family these days. Though until a few months ago his life was doubtless no more exciting than most, today he is a very busy man indeed. As Director of Aircraft Sales for American Airlines he must see to it that his company enters the jet age with a minimum of ballast in the shape of surplus piston-engine transports and at the same time with good hard cash in the coffers. In February 1958 he successfully disposed of thirty Convair 240s, and in September of another 24 of these aircraft. At the moment he is conducting a sales campaign for Douglas DC-6s and DC-6Bs, in which American Airlines offers, as an additional attraction to buyers, to train customers' flight personnel, top mechanics, communication and radio technicians, and specialists in sales and advertising.

Needless to say, Barrie is not alone in his efforts. A round two dozen airlines, in both the Old and the New World, are moving heaven and earth to be " in funds " by the time their jet aircraft are delivered.

The aircraft sales programme, however, is only part of the financial preparations for jet services and, to be fully understood, it must be seen against its overall background.

★

In August 1958 the White House published a report on the resources open to the U.S. airlines to finance the turbine aircraft fleets they have ordered. This was the famous Cherington Report prepared by Professor Paul W. Cherington, of Harvard University, as part of a wider survey of the economic situation in the U.S. air transportation industry.

According to the Cherington Report, the U.S. domestic trunk airlines will have to find a total of $ 2,800,000,000 by 1961 to pay for the some 400 turbine aircraft on order (plus a certain number of new piston-engine transports) and the modernization of their ground services. The total includes the sum of $ 2,600,000,000 for aircraft alone.

The airlines hope to cover a proportion of these commitments from reserve funds, operating profits and the proceeds of the sale of surplus piston-engine aircraft. Counting loans and stock issues, however, there still remains a total of over $ 763,000,000 to be found, adds the report. A breakdown of this figure among the individual airlines reveals the following picture :

Company	Finance still required (millions of $)
American	31.9
Capital	53.5
Continental	17.8
Delta	28.8
Eastern	22.6
National	47.5
Northeast	26.3
Northwest	63.5
Pan American	115.3
Panagra	18.0
TWA	313.3
United Airlines	8.0
Western	17.2
	763.7

In other words, every cent counts, and both American and non-American airlines will leave no stone unturned to dispose of their surplus equipment on the most favourable possible terms.

How many surplus piston-engine aircraft will be seeking purchasers ?

According to estimates prepared by the U.S. authorities and aircraft manufacturers, the U.S. airlines and armed forces will replace some 2,000 piston-engine civil and military transports with turbine aircraft during the next three years. Of this total around 800 will come from the airlines. At the same time non-American operators are expected to offer another 1,400 aircraft for sale.

That it will be no easy matter to find purchasers is indicated by the fact that in the *past* three years only 605 used American transports have been sold on the world market.

★

A refreshing note is sounded by the undaunted optimism with which certain aircraft dealers are approaching the problem. For example, America's " Newsweek " magazine recently introduced its readers to an enterprising young man by the name of Frederick B. Ayer : 30 years old, broad-shouldered and 6 feet tall, energetic, fast-talking... the picture is clear.

Ayer radiates confidence. He feels the airlines are too gloomy : " They aren't aircraft peddlars ", he says. " They're not geared to do the job. I am. "

Formerly merely an agent for buyers and sellers, Ayer has of late been working on his own account. His latest big deal was the 24 American Airlines Convair 240s mentioned earlier, for which he paid cash. Ayer has not the slightest doubts about being able to resell them for $ 250,000 apiece.

★

With all due respect to this young aircraft dealer's courage, Ayer rather resembles a front-line officer who sees only a relatively small sector of the battlefield and believes the war to be won when all goes well with his company.

By contrast, the " staff officers "—i.e., the responsible planners in airlines, aircraft manufacturing industry and government agencies—are a good deal more reserved in their assessment of the situation.

For instance, the Aircraft Industries Association of America recently submitted a study which pointed out that " now that so many used aircraft are suddenly thrown on the market, this availability has depressed market prices by as much as 50 percent. This indicates a saturation of the cash customer market... there are presently not enough cash customers in the world to absorb the large quantities of Convairs, Martins, Constellations, DC-3s, DC-4s, DC-6s, DC-7s, Stratocruisers, etc. Therefore many airlines are apprehensively reappraising their commitments to buy new jets and, unless means can be found to open a greater market for their redundant aircraft, there may well be a rush of cancelled jet transport orders which would hit the American aviation industry much harder than its competitors. "

The solution proposed by the AIA study is a bigger export drive for used American aircraft, particularly to under-developed areas, with the Export-Import Bank or similar agency providing solvent customers with loans. It rejects the suggestion that aircraft manufacturers should take back used aircraft in part payment for jet transports. This would merely be shifting the burden of unused fleets from the airlines to the manufacturers, who would have exactly the same difficulties in disposing of them. Their salesmen are trained to sell new aircraft and would not necessarily know how to cope with other companies' models.

Another proposal recommends the formation of a reserve fleet of surplus military and civil aircraft for use in emergency, on somewhat the same lines as the U.S. Navy's " mothball " programme for warships.

★

All these suggestions so far are of pure American origin and may in some cases conflict with the requirements of other continents. It may be that a satisfactory solution to this disturbing problem—like many others—can be found only if it is tackled on a word-wide basis. If every country acts independently the result might well be that the unsaleable aircraft wander from continent to continent, without increasing their chances of finding a purchaser.

October 1908 : Emil Messner's World Balloon Record

The Swiss Aero Club has just been celebrating the victory of the Swiss free balloon " Helvetia " in the second Gordon Bennett contest on October 11th to 14th, 1908. Manned by Colonel Th. Schaeck (at that time President of the Swiss Aero Club) and Lieutenant Colonel Emil Messner (later Colonel, Central President of the Swiss Aero Clubs and first Board Chairman of Interavia), the balloon set up a world endurance record by flying the 1,190 km from Berlin to Bergset, Norway, in 72 hours 25 mins after drifting across the North Sea.

INTERAVIA Essay Competition

December 31st, 1958 (12 noon) is the latest date for receipt of entries for the INTERAVIA Essay Competition. All manuscripts (type written, in 2 copies) must then have reached the Secretariat, INTERAVIA S. A., 6, Corraterie, Geneva.

Rules for the contest were published in the June 1958 issue, on page 495. The two subjects on which essays will be accepted are as follows :

1. **Air Travel for All :** How can the airlines—in particular the European airlines—make air travel accessible to the broadest sections of the population, without endangering their economic stability ?

2. **Guided Missiles or Piloted Aircraft ? :** Is the piloted aircraft played out, must it abdicate in favour of the guided missile, or will the two weapons continue to exist side by side for a long time to come ?

INTERAVIA S. A., Geneva

INTERNATIONAL MEETINGS AND CONFERENCES

Nov. 3rd : Society of Instrument Technology Conference — "Instruments for Guided Flight". Cheltenham, England.

Nov. 3rd-7th : Universal Air Travel Plan, Special Meeting. Silvermine, Conn.

Nov. 6th-7th : IAS — National Specialist Meeting on Dynamics and Aeroelasticity. Fort Worth, Texas.

Nov. 6th-7th : Institute of Radio Engineers 5th Annual Meeting — Professional Group on Nuclear Science. San Mateo, Calif.

Nov. 9th-12th : National Defense Transportation Association — Annual National Convention and Logistics Forum. St. Louis, Mo.

Nov. 10th-12th : School of Aviation Medicine — International Conference, Physics and Medicine of the Atmosphere and Space. San Antonio, Texas.

Nov. 10th-13th : Flight Safety Foundation — 11th Annual International Air Safety Seminar. Atlantic City, N.J.

Nov. 11th-14th : National Aviation Trades Association 19th Annual Convention. Milwaukee, Wisconsin.

Nov. 12th : Society of Instrument Technology — "Some Applications of Control Technique in Astronomy". London.

Nov. 12th-14th : ATA — Airline Finance and Accounting Conference. Miami Beach, Florida.

Nov. 12th-14th : Vickers Inc., Division of Sperry Rand Corp. — 8th Aircraft Hydraulics Conference. Detroit, Michigan.

Nov. 12th-14th : Society of Stress Analysis Annual Meeting. Albany, N.Y.

Nov. 13th : ATA — Public Affairs Committee Meeting. Washington.

Nov. 13th-14th : National Security Industrial Association — Symposium on Molecular Electronics. Washington.

Nov. 16th-21st : Conference on Scientific Information — AFOSR Directorate of Research Communication, NAS, NSF and the American Documentation Institute. Washington.

Nov. 17th : ICAO — Vertical Separation of Aircraft Panel, 3rd Meeting. Montreal.

Nov. 17th-18th : American Society for Quality Control 6th Annual Aircraft and Missile Division Conference. Dayton, Ohio.

Nov. 17th-21st.: ARS — 13th Annual Meeting and Astronautical Exposition. New York.

Nov. 18th : ICAO — Statistics Division Meeting, 3rd Session. Montreal.

Nov. 18th-20th : Aviation Distributors and Manufacturers Association Meeting. Dallas, Texas.

Nov. 18th-20th: ATA — Air Traffic Conference. Houston, Texas.

Nov. 24th-27th : IATA — 4th Public Relations Conference. Hamburg.

Nov. 28th-Dec. 4th : Electronic Computer Exhibition. London.

Nov. 30th-Dec. 5th : American Society of Mechanical Engineers Annual Meeting. New York.

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New York Finance Notes

U.S. Air Transportation and Aircraft Industry in mid-October 1958

BY SCOTT HERSHEY, NEW YORK

The stock market which broke all manner of records in September continued its advance into October recording the highest prices on record and the greatest volume for a month since September, 1929. The direction of the market definitely was up —not riotously, but steadily.

There were some overtones of inflation fears, and there were some warnings that the market was ahead of business recovery. But there was favorable economic news, and indications of less tension around Formosa, and these items seemed to bolster the confidence which continued to send the market up.

The strongest groups in the surging market were the aluminums, motors, mining, drugs, radio-TV manufacturing, surprisingly the rails and in this connection the airlines also did well. The issues also had the advantage of trans-Atlantic jet service inaugurated by BOAC and the upcoming service of Pan American.

The airlines were in the groups which were up 5 to 10 percent. Percentage changes showed a plus 5.4 for July, a minus 0.3 for August and a hefty plus 8.5 for September.

The range of some of the leaders with net changes from the end of August showed : American Airlines 23 5/8-21 ½, plus 1 5/8 ; Capital Airlines 15 5/8-21 ¼, plus 7/8 ; Pan American 21 7/8-17, plus 4 ½ ; TWA 13 ¾-13 ¼, plus 1 ¼ ; and United Air Lines 30 ¼-28 1/8, plus 1.

KLM, Royal Dutch Airlines predicts a profit for 1958. In 1957, KLM earned $ 5,687,000 or $ 4.22 a share, but the carrier lost $ 251,000 in the first half of this year, largely because of a loss of Indonesian routes and a pilots' strike.

American, for the first seven months was up to $ 182,000,000 from $ 179,000,000, with profits, after allowing for capital gains, of $ 9,000,000 or $ 1.09 a share. This compared with $ 7,700,000 or 92 cents a share a year previous.

Northeast has recorded sharp increases in revenues this year over 1957, but expenses have risen even faster, particularly on the new Florida service. During the first six months revenues rose to $ 11,400,000 from $ 6,100,000 the year previous. The line showed a net loss of $ 3,300,000 for the first half of this year, however, compared with a loss of $ 1,500,000 the previous year.

Delta seemed to be having a little difficulty and announced that commitments on two of the eight DC-8 jets on order had been deferred. They were scheduled for 1961 delivery. Delta earned 95 cents per share on operating revenue of $ 1,941,746, as against $ 2.34 earned per share on $ 5,528,646 last year.

★

Despite the volatile market, the aircrafts, for the most part, were among the backward groups. This situation was attributed by some Wall Streeters to Defense Department moves, where one day there are reports that the missile program will be cut back and the next day a denial and the third that it is being accelerated. It is similar to a situation of a year ago when the Pentagon stretched out payments—a situation commented upon here—and also cut back some contracts and cancelled others outright.

Among the aircrafts, typical issues showed these ranges : Boeing 48 1/8-43 7/8, plus 2 ½ ; Douglas 63 3/8-57 5/8, plus 3 1/8 (the best performer); and United Aircraft 66 ½-62 5/8, minus 1 ¼.

Aircrafts generally performed in the groups up 0 to 5 percent, with an overall plus 4.5 in July, minus 2.4 in August and plus 2.6 in September.

Just which aircraft-missile maker issues will prove most attractive depends to a large extent on the importance of future projects. If, for example, the Navy relies heavily on submarine-launched missiles, this could mean important business for Lockheed, prime contractor for the 1,500 mile *Polaris*.

There is considerable interest in the *Minuteman*, a solid-fuel missile which can be used as a three-stage intercontinental missile, or a two stage intermediate range weapon. There are five companies involved in the research and development of this one : North American, Avco Manufacturing, Thiokol, Aerojet and Hercules Powder.

North American has also been given a development contract for the B-70 exotic-fueled bomber which is slated to have a speed of over 2,000 m.p.h. and which may eventually be the successor to the Boeing B-52 as the chief long-range piloted bomber. Boeing is scheduled to deliver advanced B-52 models through 1960, and meanwhile is moving into increased production of the *Bomarc* missile, powered by Marquardt Aircraft's ramjet engine.

The activities of the companies involved should be of interest to investors in this field. However, aircraft manufacturers, in some cases, not only are faced with problems from growing emphasis on missiles. In some cases they are writing off development costs for commercial jet airliners. Heavy cash demands in connection with the DC-8 program are believed to have had some effect on the decline in Douglas earnings. Boeing, Lockheed and the Convair Division of General Dynamics are faced with similar problems.

Douglas has the largest proportion of its latest backlog in commercial orders—51 percent against 31 percent for Boeing, 30 percent for Lockheed and 21 percent for General Dynamics.

It is interesting to note that the six leading companies in this field—Boeing, General Dynamics, North American, United Aircraft, Douglas and Lockheed—account for about 70 percent of the total sales volume, while the remaining 14 companies in the top twenty provide only 30 percent.

It would appear, then, that for the average investor who wants to get into this volatile group, the industry's top six look best, although the smaller and more speculative situations could be interesting for the venturesome type of security buyer.

Some of the top missile-rocket makers and recent prices show : Boeing, 45 ; General Dynamics, 61 ; North American, 34 ; United Aircraft, 65 ; Douglas, 58 ; Lockheed, 53 ; Curtiss-Wright, 29 ; McDonnell, 32 ; Martin, 32 ; Republic, 27 ; Northrop, 28.

Reports on earnings per share for the first six months of this year show : Boeing, $ 2.78 ; General Dynamics, $ 2.04 ; North American, $ 2.27 (nine months); United Aircraft, $ 3.43 ; Douglas, $ 3.41 ; Lockheed, $ 2.56 ; Curtiss-Wright, $ 2.72 ; Martin, $ 1.23 and Republic, $ 1.04.

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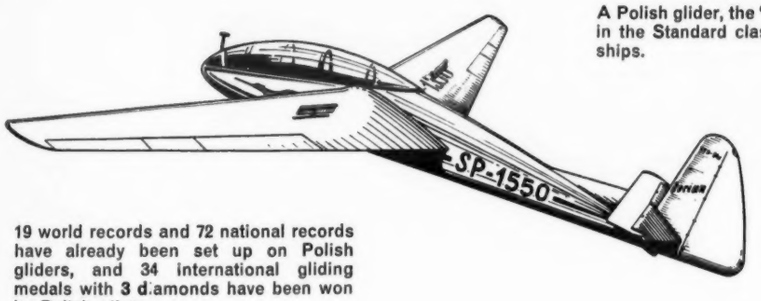

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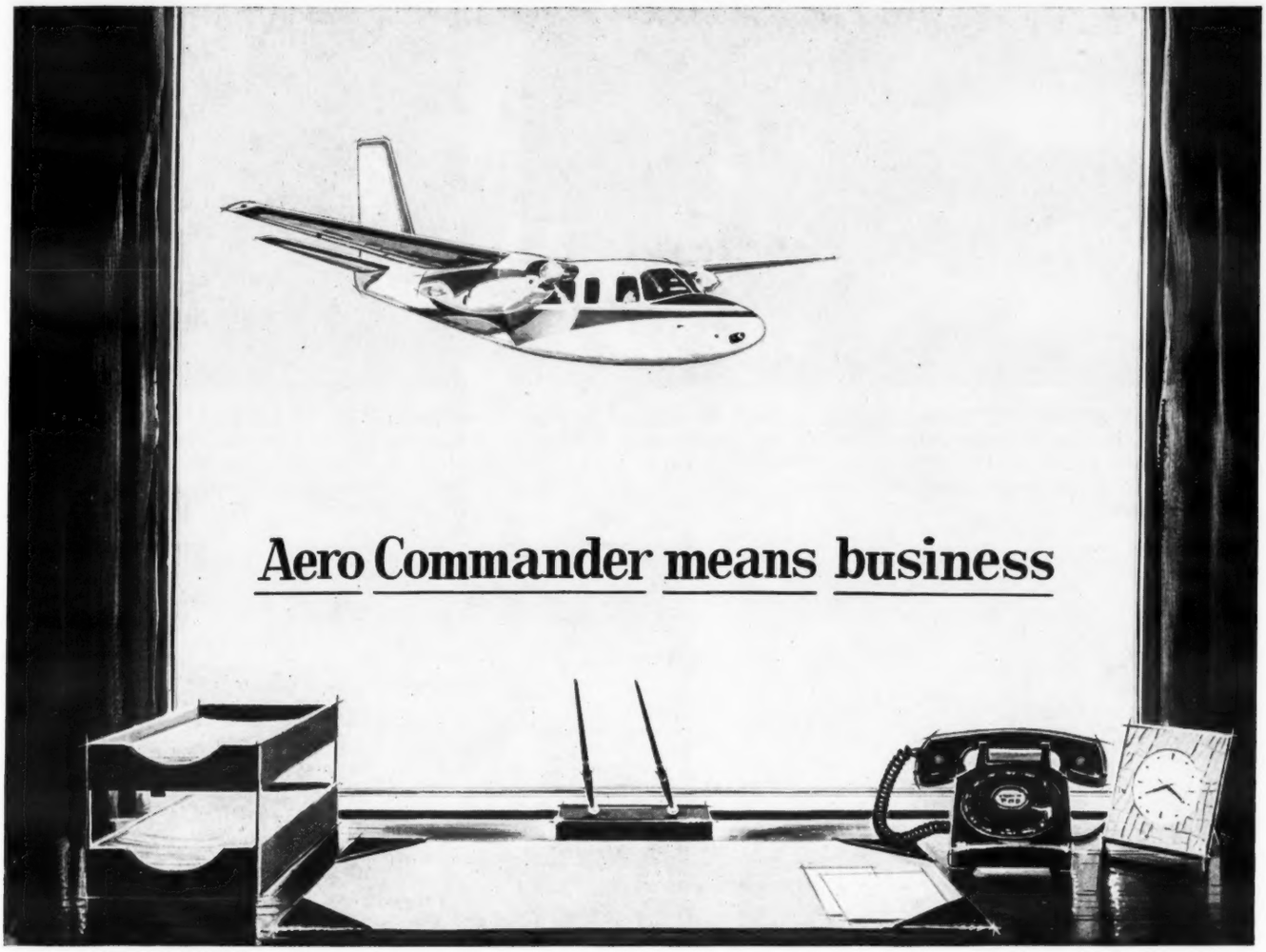

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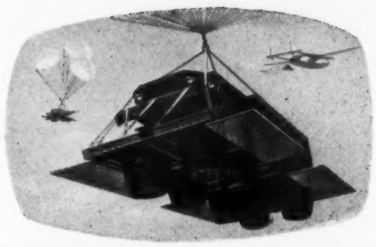

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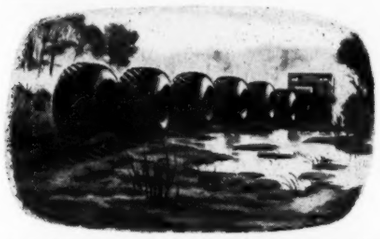

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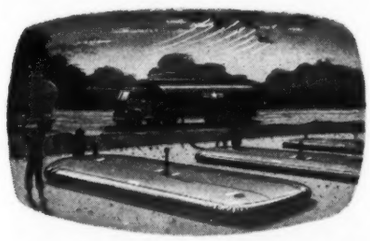

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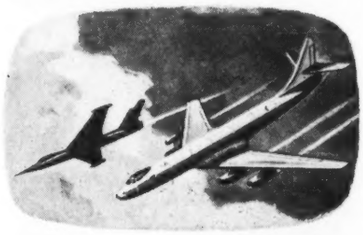

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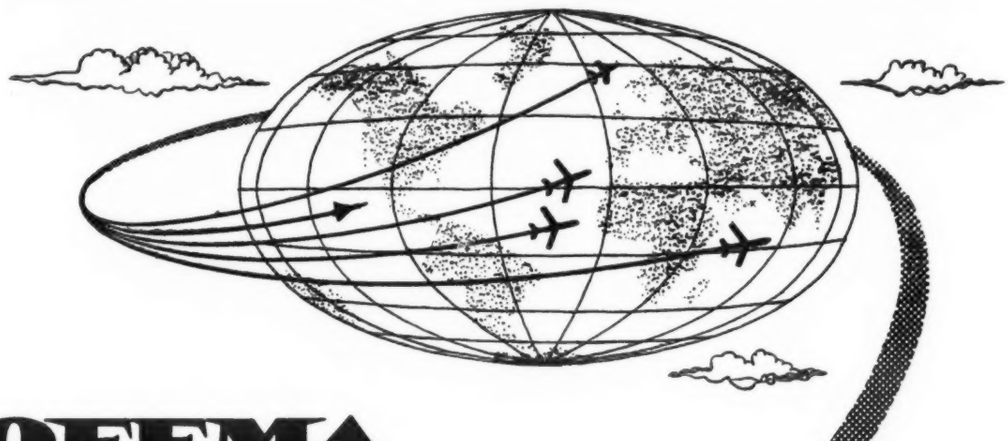

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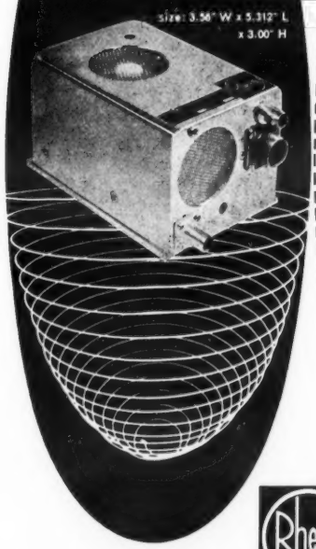

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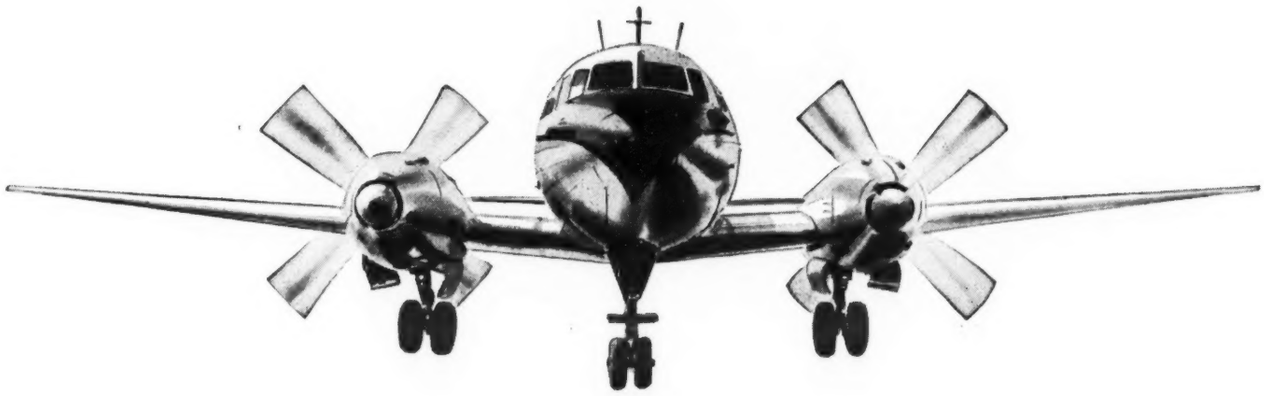

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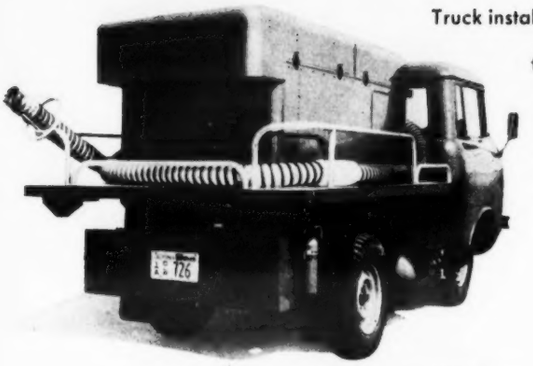

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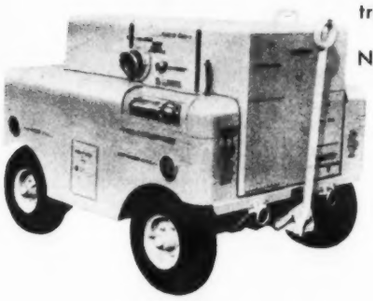

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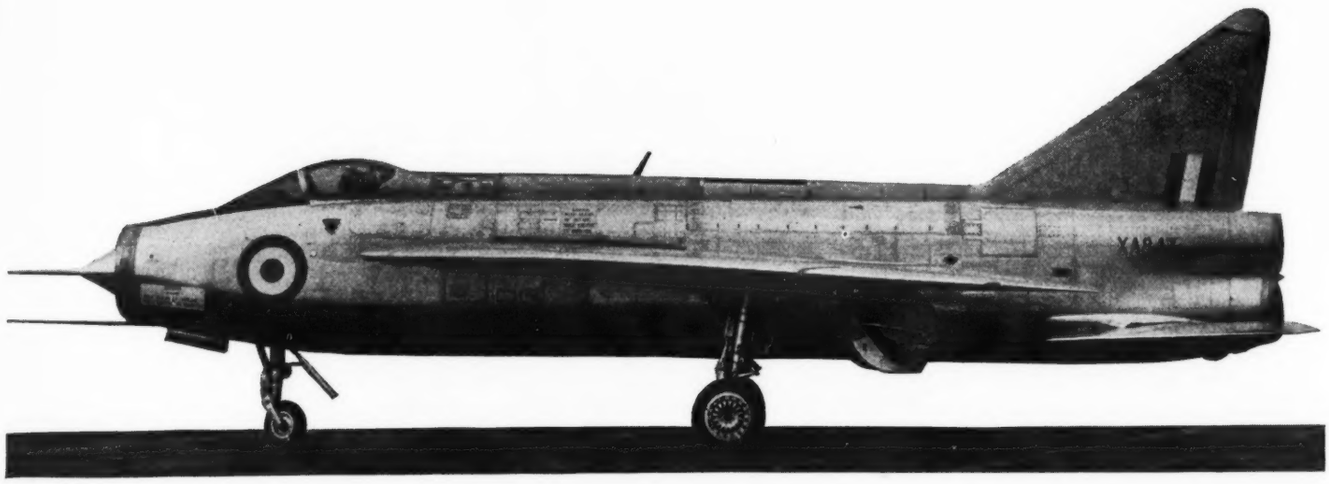

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An Interim Account of Tactical Missiles

Revising Over-Hasty Concepts

Lieutenant General James M. Gavin, retired, whose recently published book "War and Peace in the Space Age"* seems destined to become a military best-seller, is a man of courage. A successful combat officer and former commander of the U.S. 82nd Airborne Division, he later became Chief of the U.S. Army's Research and Development where he came into conflict with Defense Secretary Wilson over the preparation of the guided missile programme. As a result he retired to take a post with a private company. His book is a kind of apologia for his attitude, though at the same time it remains constructive, since he also outlines the military and political principles which he considers would lead to success.

General Gavin reports once having heard former Secretary of Defense Charles E. Wilson, who for a number of years was responsible for the United States' arms policy under the Eisenhower Administration, make the following statement:

"We can't afford to fight limited wars. We can only afford to fight a big war, and if there is one, that is the kind it will be."

The events of recent months—to mention only the Suez crisis, the fighting in North Africa, the threats in the Near and Far East—have shown how far Wilson was mistaken. But his mistake had far more serious consequences; it threatened to overturn the whole arms policies of the United States and its Allies, and brought unrest and serious difficulties to the West's arms industry, particularly the aircraft industry. The panacea of threatening with the atomic "big stick", which was considered capable of preventing all war, including perimeter wars, has proved to be invalid. But, as will be recalled, this concept was at the bottom of the famous British White Paper, whose pronouncements had to be largely reversed a year later. This concept caused uneasiness in French and Italian defence circles and had a blighting effect on the rearmament of West Germany, who began to wonder whether it was worth the expense of setting up an air force of manned aircraft. Recent events, however, have taught many lessons and introduced a certain order into the confusion. And General Gavin writes as follows on the mistakes of Wilson and his entourage:

"Limited war is a more highly specialized form of combat than global war, and we had better realize it and do something about it. It makes little sense to assume that, if you have the power to wage general war successfully, you can, by using a little bit of that capability, *ipso facto,* wage a little war. A thermonuclear-equipped B-52 can contribute little more to the solution of a limited local war than a 155-mm gun can contribute to the apprehension of a traffic violator."

It was not until the Paris NATO meeting in December 1957, after stormy discussions behind closed doors, that the picture really became clearer, and the West gradually began to turn back to normal arms planning: limited wars are by no means impossible, not all conventional weapons belong on the scrap heap, the day of the manned fighter is definitely not past, and the big stick on both sides may prevent the worst but will not cope with all threats.

*

Wilson accepted the consequences of his error, and men like General Gavin or Marshal of the Royal Air Force Sir Dermot A. Boyle, Chief of the Air Staff, who had fought for the retention of his Fighter Command, have been proved right. In the United States the arms industry noted with misgivings the over-hasty concept of "Engine Charlie"—who as President of General Motors had been a successful industrialist, but was to prove unfortunate as Defense Secretary—and had to accept a stretch-out in the production programme for conventional weapons. However, industry leaders had seen to it, sometimes on their own initiative, that developments were not all shelved. For example, development of the Century Series of fighters continued more or less undisturbed: the North American F-100 was followed by the Convair F-102, the Lockheed F-104 and Convair F-106, and now there is talk of a North American F-108 superheavy interceptor.

The *Sidewinder* air-to-air missile is now part of the arsenal of the USAF's 83rd Fighter-Interceptor Squadron at Hamilton Air Force Base.

The U.S. industry, however, did a great deal more. Its experts had recognized that conventional aircraft cannon alone did not suffice as means of defence against modern bombers. Experience of unguided rockets in the Korea war was promising (the development of the Swiss Oerlikon rocket may well have had some influence here). These early rockets have since been followed by a *whole arsenal of small and medium tactical guided missiles for Army, Navy and Air Force.*

*

At a time when the public reads almost daily of new American or Russian tests with large, long-range missiles, the discussion of these smaller weapons may seem vastly less sensational. Yet it is these weapons which in all probability would be decisive in limited wars, and would also be indispensable in certain phases of a major war.

Because of the confusion introduced only a few years ago, all the Western countries, with the possible exception of Britain, have hitherto neglected this line of development. Now military missions from the Allied countries are visiting the United States to inspect the new small "wonder weapons".

Some of them may well be surprised to learn that these new weapons are certainly not designed for the "little man", but are definitely costly equipment. One of the simplest air-to-air rockets for manned fighters, the Philco *Sidewinder*—some of which appear to have been used in the Straits of Formosa—is reported to cost roughly $5,000 in large-scale production; the price of a single rocket of the *Falcon* series is said to be between $12,000 and $19,000; and a really modern air-to-air guided missile, with atomic warhead, will probably cost several times this amount.

As even a relatively small country needs large numbers of aircraft rockets, an investment of several dozen million dollars will be required. In addition to the still indispensable procurement of fighters, tanks and similar conventional weapons for air and surface warfare, every country anxious to provide itself with valid armaments will find further massive expenditure inevitable, on missiles for anti-tank operations and support of the ground fighting, tactical surface-to-air rockets for the defence of strategic points, etc.

*

Over-hasty concepts are gradually being abandoned. Hence it seems opportune to render an interim account of the tactical missiles which to-morrow will doubtless form part of the defensive arsenal of all countries.

EEH

* Harper & Brothers, New York

Tactical missiles

Back to the Conventional

By General (Ret'd.) P. M. Gallois, Paris

The watchful observer today will readily detect yet another switch in the West's defence policies. Already the vast arms production machine is turning in a new direction. The 1960 budget being prepared at the Pentagon may well confirm the Congress decision not to reduce the strength of the Army or the Marine Corps, leaving these two services untouched at the expense of Strategic Air Command. The British authorities are revising the five-year defence plan. A middle way is being sought between the armed forces of World War II and the type of forces envisaged by the 1957 White Paper on Defence. Why?

- Firstly because, though both power blocs now possess thermonuclear weapons, this has not stabilized the world situation.

- Secondly because missiles are virtually useless without nuclear warheads. The some 400 V2s which fell on the London region during World War II claimed many victims, but in no way affected the course of the war. Since the end of the war, the West has repeatedly been faced with aggressions of too minor a scope to justify recourse to the "ultimate" weapons which it possesses.

- Finally, there is a third explanation of why the pendulum of Western strategy is swinging back towards the "conventional", after having been directed towards the "nuclear". Unlike the West, the Soviet Union with its monolithic structure and its intelligent planning can afford a complete range of armaments, from the infantryman to the long-range ballistic missile.

The following table provides a broad classification of the different forms of threat and the appropriate weapons to counter them.

So far, fortunately, the first two threats have been purely theoretical. Nevertheless, the appropriate arms have been acquired, which is doubtless the reason why they have remained hypothetical. But although the world has already experienced the other threats, the West is still not equipped to meet them.

General war	● Strategic bombers, air-to-surface missiles, ICBM and IRBM, missile submarines. ● Radar. Surface-to-air missiles, interceptors, air-to-air missiles. ● Strategic transports (to supply bases in peacetime and rehabilitate the territory after the nuclear phase of a war).
Local atomic wars	● Tactical bombers, fighter-bombers. Air-to-surface missiles. Battlefield ballistic missiles. Missile submarines. ● Radar. Surface-to-air missiles, interceptors, air-to-air missiles. ● Strategic transports (in peacetime and during operations). Tactical transports. Airborne forces (aircraft, helicopters).
Local conventional wars	● Tactical bombers, fighter-bombers, air-to-surface missiles. Aircraft carriers. ● Radar. Surface-to-air missiles, interceptors. ● Strategic and tactical transports. Airborne troops (aircraft, helicopters).
Idealogical aggression leading to guerilla war	● Tactical and strategic transports. Airborne troops. Strike aircraft.
Blackmail and threats of armed warfare (ultimatum based on nuclear or conventional threat)	● The existence of even a small aero-nuclear force would discourage recourse to this type of blackmail.

General war impossible, if . . .

Basically, general war, or in other words the recourse to the indiscriminate and unlimited use of nuclear weapons, can be imagined only if the vital interests of one of the two Super Powers were threatened by the other. Just where the dividing line falls is at present by no means clear. In the West it covers Western Europe and all the NATO countries and, more generally, all the territories which Washington has hinted will be considered as much the flesh and blood of the United States as Florida or Nebraska. A modern version of the famous saying "our frontier is on the Rhine", this kind of guarantee calls for prudence on the part of a would-be aggressor when assessing possible American reactions.

The pattern of such a generalized war and the weapons which would be used have been discussed so often in these pages that they are already familiar to readers. It suffices, therefore, to recapitulate the essentials.

1. An all-out surprise attack would be aimed firstly at destroying the West's reprisal forces. The less efficient the aggressor's own defences, the more imperative it would be to destroy a high percentage of these forces while they are still on their bases.

2. If the initial assault attains its aims, two hypotheses are possible:
- either the West asks for terms, having lost its means of retaliation;
- or it resists, and a new attack — this time directed against a few "guinea pig" cities — creates the conditions for immediate surrender, since negotiation would be preferable to general annihilation.

3. If, on the other hand, the initial attack does not entirely succeed, the retaliatory raids would probably exceed the quantity of destruction which the aggressor could absorb without his structure as an organized State being destroyed. In any case, the "affair" would be brief, at any rate the nuclear portion of it.

For the West, there are five requirements in the nuclear field:
- To possess a nuclear reprisal force;
- To guard the essential portion of this force at all times against the effects of a surprise attack (by mobility, for example, or by dispersion in space on the SAC principle);
- To make sure that this reprisal force has an adequate penetration power, i.e., that it would reach its targets despite the enemy defences;
- To build up a defensive system to complement the passive defence measures protecting the reprisal force and designed to complicate the attacker's task;
- Finally and above all, to make it clearly understood that reprisals would automatically follow any aggression.

Launching a Martin TM-76 *Mace* tactical surface-to-surface self-guiding missile with the aid of a booster rocket of roughly 100,000 lb. thrust.

With its self-propelled cross-country mount, on balloon tyres, the *Mace* surface-to-surface missile is a highly mobile weapon system which can attack tactical targets over a range of more than 600 miles.

Under these conditions the deterrent would be effective. Obviously the most difficult of these five requirements is the last mentioned. The greater the strength of the deterrent, the more cautiously it may have to be used and hence the less efficiently it does its job.

This is the Western World's big problem. This is what has divided the Pentagon on the subject of allocating military funds and is at the bottom of the rivalry between the USAF and the U.S. Army. Fundamentally it is the problem of the free world's attrition through local conflicts which thermonuclear weapons cannot prevent. As the years pass it becomes more and more obvious that this deterrent force plays a vital role—though a role limited to a single type of situation. This is the argument put forward by all those who are not satisfied by the deterrent policy.

Local atomic war: speculation or reality?

It was in 1955, after the Indochina war, that the National Security Council agreed to supplement the "big deterrent" with the instruments of a "small" or "tactical" deterrent. This move had a two-fold aim: it made use of the latest technical developments and the perfecting of low power atomic weapons; it enabled manpower strength to be reduced and hence considerable economies to be made all round, while at the same time greatly increasing fire power.

The new arsenal was soon got together, with the 280-mm gun, such missiles as the *Honest John, Redstone, Corporal, Matador* and *Regulus,* atomic land mines and depth charges, fighter-bombers and light bombers, each now capable of carrying the equivalent of several thousands tons of TNT in nuclear explosives.

The new complementary strategy received its letters of patent even before it had assembled its resources. In February 1956, Donald Quarles, then Secretary of the Air Force, stated that the United States would use their nuclear arsenal in the event of a limited war. And on April 15th, during a meeting of a United Nations disarmament committee, Harold E. Stassen officially warned Soviet delegate Zorin of the new American policy of "limited deterrence". A year later, in a resounding article in "Foreign Affairs", Mr. Dulles himself maintained that "brush fires" could also be dealt with with the aid of the new nuclear weapons of limited radio-active effects. And General Taylor, Chief of Staff of the U.S. Army, stated that "tactical atomic weapons would be used in local conflicts *if the victim of the aggression agreed.*"

Return to the conventional

For their part, the British also accepted the principle of this new use of the nuclear explosive. The availability of small calibre weapons (equivalent to 500 to 1,000 tons of TNT) would enable the NATO "shield" forces to be equipped with nuclear weapons and hence permit a reduction in manpower strength accompanied by an increase in firepower, it was argued. This is true in theory. But it remains to be seen whether the West would dare to use these low-power atomic weapons, knowing that this might well be the first step towards the introduction of increasingly powerful warheads into the struggle.

An English Electric *Thunderbird* surface-to-air missile is moved into position on its mobile launcher, erected and prepared for firing.

It will be argued that in the TNT age it was found possible to limit the weapons used. But this was due to two factors: firstly, the effects of conventional explosives are finite and controllable; secondly, the targets attacked in these cases did not require use of the biggest bombs (in the Korean war, for example, neither the Japanese ports nor the Manchurian bases were attacked). But what would be the advantage of such a closed field in which the belligerents would blast each other with atomic bombs, leaving the victor in possession of a ravaged and contaminated territory?

In any case, the theory of "limited deterrent" has so far not been a particularly happy one. The adversary can always trigger off a conflict under conditions in which weapons as undiscriminating as nuclear warheads—even of low power—prove to be impossible to use.

The wheel has come full circle. Though we are now tending to return to our point of departure, we have acquired en route both large and small calibre nuclear weapons, offensive and defensive missiles, the "sky cavalry" and flying jeeps, the pentomic divisions, light tactical fighters and, tomorrow, VTOL aircraft. Both military leaders and engineers must seek a new concept, which will also meet with the approval of the taxpayer now crushed under the burden of the expanding arsenal. The need is to develop multi-purpose techniques which will be valid within the framework of several strategic hypotheses. The effort of imagination required in the study of nuclear warfare will have borne fruit. We shall have learned the virtues of mobility, of lightness in weight, of instantaneous reaction. It so happens that these same virtues are also required for "sub-atomic" conflicts.

With the introduction of ballistic surface-to-surface weapons such as *Sergeant, Redstone* and *Pershing*, the U.S. Army has enlarged its radius of action by hundreds of miles and can now attack enemy assembly areas behind the fighting zone. Even the "short-range" *Corporal* rocket shown here can carry an atomic warhead over more than 75 miles.

This weapon system escapes premature detection by the enemy by travelling underwater to its operating area, surfacing unexpectedly and firing on targets more than 1,000 miles distant. The system is a combination of a submarine with the Chance Vought *Regulus II* self-guided missile, here seen being prepared for launching after its carrier, the *U.S.S. Grayback*, has surfaced.

Tactical missiles

United States Army Tactical Surface-to-Surface Weapons

By Major Patrick W. Powers, U. S. Army

A U.S. Army light tank and a truck launcher with an *Honest John* rocket moving into position. Picture was taken during maneuvers by the 1st U.S. Cavalry Division in Japan last winter.

No one can precisely predict the nature and course of future warfare. It is necessary then to continually develop and produce weapons that will meet the potential threats of a future battlefield—large or small, nuclear or non-nuclear. The objective of the tactical surface-to-surface missile weapon program of the United States Army is to provide our land forces with the most effective weapon systems to attack these potential threats.

The environment in which these new weapons will be used may be unlike that of any war in the past. The principal changes to the battlefield are the introduction of the nuclear warhead and the telescoping of reaction time to any military situation. These changes in turn have reoriented tactical operations and the logistical concepts necessary to support them. Increased mobility of men, weapons and equipment has become necessary as well as a reorganization of the tactical units that will operate against any future enemy. To successfully face the nuclear firepower and the manpower superiority of a potential enemy, the new tactical organizations—such as the Army's five-sided "Pentomic" divisions—must be more mobile and flexible in operation than the opposing forces. This also must be characteristic of the weapon systems employed. They must be lightweight, rugged, simple in operation and maintenance, reliable and more lethal than ever before.

It is within this framework of the operational requirements of the future battlefield that the present surface-to-surface weapons were developed. Each has a specific mission to accomplish in the form of the attack of three principal types of target: (1) tanks, (2) front line troops and (3) personnel, equipment, and installations at ranges up to hundreds of miles.

1—Versus tanks

The *Dart* is the anti-tank guided missile designed to destroy tanks beyond the effective range of their own guns. It is only 5 feet in length with a 3-foot wingspan and weighs less than 100 pounds. The main advantages of the *Dart* over conventional guns are its longer effective range and its ability to cope with a moving tank. The guidance system utilizes signals sent over trailing wires from the missile. The *Dart* is fired from a simple, lightweight launcher that can be mounted in a jeep, tank or aircraft. Once launched it has sufficient velocity to be relatively safe from rifle, machine gun and anti-aircraft fire with a high probability that a single round will destroy the target.

2—Versus front line troops

The *Lacrosse* was developed to attack the second category of targets. These close-in enemy troops can either be out in the open or protected by the largest pillboxes or bunkers. This missile has the range of general support artillery. The 20-foot, solid propellant weapon is launched from a conventional 2½-ton Army truck some distance behind the front lines. The position of the truck is known to an observer with the guidance equipment located at the front lines within sight of a pillbox target. The guidance system sends commands to the missile as it comes overhead and directs it into a nearly vertical dive into the pillbox. The uncanny accuracy of the *Lacrosse* to hit a point target is its most outstanding characteristic.

The *Lacrosse* system represents a major improvement in the design of a weapon to

Members of the U.S. Army's 7th Field Artillery (Rocket) Battalion loading an *Honest John* rocket from its carrier (foreground) on to the mobile launching platform (left) at Grafenwöhr.

The *Honest John* resting on its launcher, which has been erected and pointed in the direction of the target.

Little John artillery rocket in firing position on its mobile, two-wheel launching rig.

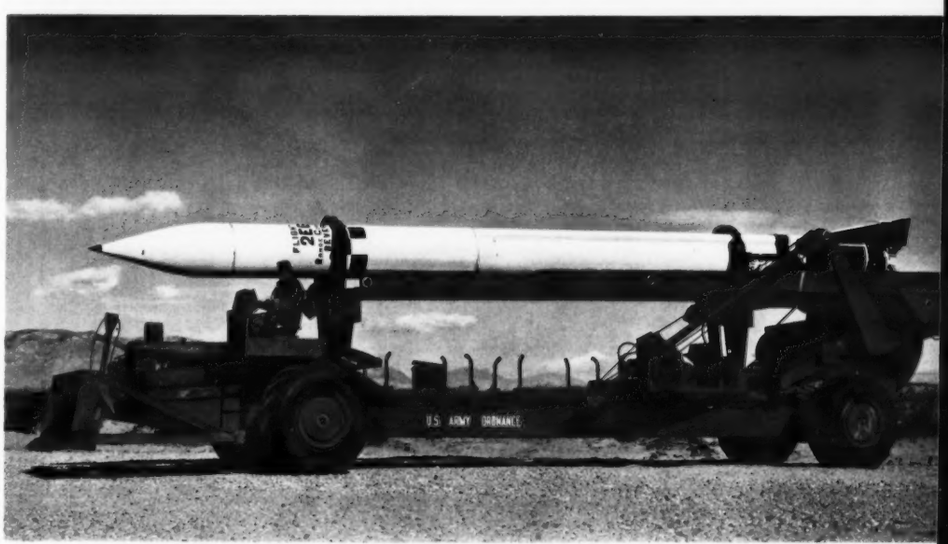
A *Lacrosse* guided missile immediately before launching from its carrier truck. The man at the rear of the truck is checking the firing direction. Once launched, the missile is guided to its target by a control post further forward.

give close fire support to the front lines and to attack strongpoints. It has the mobility of the 2½-ton truck and the reduced field handling characteristics of the solid propellant rocket. All of its launching equipment is carried on the truck that mounts the missile. Checkout of the missile is done automatically by a sequential checker on the truck. The forward guidance equipment can be man-packed in any type of terrain. All of these characteristics will insure a rapid, accurate and effective engagement of ground targets close to the front lines.

3—Versus personnel, equipment, and installations

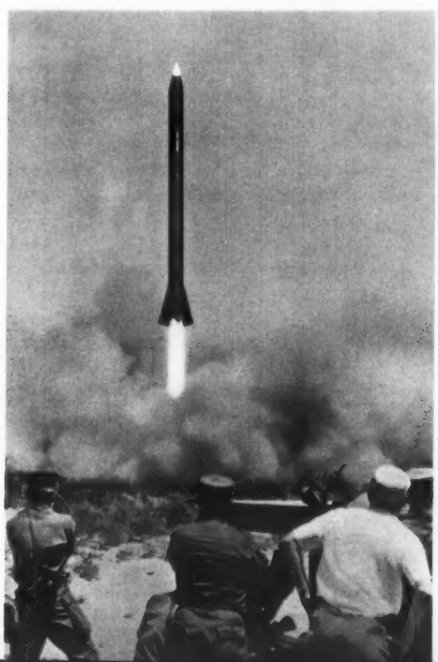
This broad group of targets is usually identified in terms of range and so are the surface-to-surface weapons that have been produced to attack them. All of these weapons have a nuclear warhead capability with the shorter range missile possessing a high explosive warhead choice as well. The shortest range rockets, the *Honest John* and *Little John,* are unguided, resulting in simple, rugged equipment with sufficiently accurate firepower. As the ranges increase, accuracy is a problem,

A special transporter, which erects the missile and sets it on the launching pad, has been developed for the *Corporal* surface-to-surface ballistic missile.



The *Dart* anti-tank missile can be operated from a jeep and is guided to its target by wire commands, with the aid of an optical sight.

A *Corporal* short-range missile being fired at White Sands Missile Range, New Mexico.



The *Sergeant* surface-to-surface ballistic missile is erected by the cradle on the transport trailer and launched obliquely from this cradle.

When the warhead has been fitted, the four wings are snapped into place on the shell-like body (above left) ...and finally the tail fins (above right), which like the wings are held in place by retaining spring clips.

The Lacrosse surface-to-surface missile

After the *Lacrosse* has been fully assembled in an assembly area, it is moved by its transport and launching truck to the launching site, where it undergoes a thorough test procedure using a missile automatic checker mounted on the truck (below left). The firing cable is attached to the *Lacrosse's* rocket motor, the crew takes cover and awaits the firing order (below right).

and the rest of the group—from the *Corporal* to the *Pershing*—have various types of guidance systems designed to give effective results on a target commensurate with the lethal area of the warhead used.

The *Honest John* is a 27-foot solid propellant rocket made up of simply a warhead, the rocket engine and large stabilizing fins. Small spin rockets mounted at right angles to the length of the rocket impart the necessary spin or rotation at take-off to correct thrust misalignment which tends to make the rocket deviate from the desired trajectory. The rocket is elevated and turned to the desired firing azimuth to achieve the correct range and direction to hit the target. A self-propelled launcher on a 5-ton truck chassis transports the rocket on a launching rail. It can be emplaced and fired in a matter of minutes and then evacuated from the position almost immediately. It has to be an extremely mobile weapon because it will be a prime enemy target, especially when located in forward areas. This launcher and the *Honest John* have been added to all Army divisions and it can be loaded along with the divisions into cargo aircraft for action anywhere in the world. New developments for this system include a lighter launcher that can be lifted by helicopter and towed over rough terrain.

Little John is a scaled-down version of the *Honest John*. It has a length of 12 feet and weighs under 1,000 pounds. It is designed to provide the same nuclear capability but is much more easily moved about the battlefield. It is also easy to maintain, service and checkout because there are no guidance components to add complexity to the operation.

The *Corporal* guided missile system is composed of the 45-foot rocket, three vans of guidance equipment and the missile checkout, servicing and transportation vehicles. The liquid propellant rocket has a range of about 75 miles and weighs 11,000 pounds fully loaded with its propellants of nitric acid and aniline. The guidance equipment includes a radar to obtain missile position and transmit commands; a doppler-radio to measure the velocity of the missile and send shut-off and arming signals; and a computer that uses the information obtained from the radar and the doppler-radio to compute and initiate necessary commands to them.

The *Corporal* guidance system is a combination of preset and command guidance. A maneuver is preset into the missile to bring it into the radar after a vertical take-off. The radar then sends overriding azimuth commands to keep the missile on the target azimuth. At a predetermined shut-off point in space, the flow of propellants is accurately stopped and the missile is now on a true ballistic trajectory to the target. At some later

United States Army Tactical Surface-to-Surface Weapons

Target	Weapon	Assigned to	Propulsion	Guidance	Length (ft.)	Launching weight (lb.)	Range (miles)	Status
1. Tanks	Dart	Army division	SP	W	5.0	100	1.3+	Development test
2. Front line troops	Lacrosse	Army division	SP	R	19.2	n. a.	20	Development test
3. Personnel, equipment and installations	Honest John	Army division	SP	—	27.0	6,000	10+	Operational
	Little John	Army division	SP	—	12.0	1,000	10+	Development test
	Corporal	Army Corps	LP	R+RA	45.0	11,000	75+	Operational
	Sergeant	Army Corps	SP	IN	30.0	5 tons	75+	Development test
	Redstone	Field Army	LP	IN	69.0	30 tons	200	Operational
	Pershing	Field Army	SP	IN	n. a.	n. a.	n. a.	Development

Notes: SP = solid propellant; LP = liquid propellant; W = wire signals; R = radio; RA = radar; IN = inertial; n.a. = not available.

time the missile's position and velocity are again measured, and the corrections transmitted to the rocket. These corrections are stored until the missile comes back into the atmosphere when a final range correction takes place. The azimuth and range corrections are accomplished by the movement of carbon vanes during the initial portion of the trajectory, and by the steering fins for the final portion.

The sequence of firing operations for the *Corporal* is as follows: the missile is checked out in an area removed from the firing site. This is done by several technicians in a missile test station truck. The missile is then moved by a large, electrically driven erector-transport vehicle to the fueling area where the propellants are transferred from truck-mounted containers to the missile. Finally the missile goes to the launching area where it is checked with the firing circuits and erected on the launcher. In another area to the rear, the guidance vans are checked out and the fire direction center determines the equipment settings for the trajectory to the target. The settings are made on the guidance equipment and the missile. A countdown coordinates the activities of the guidance and launching areas and as the sequence reaches "3, 2, 1, fire!" the red firing button is pushed sending the *Corporal* on its mission.

The United States have had over five years of experience with this ballistic missile weapon. Based on this experience, the importance of proper maintenance and training of technical personnel has to be stressed because of the complex mechanical and electronic nature of the equipment. The design of many parts of the system should be based on "module" replacement of defective components and a simplified "go, no-go" check for proper operation. The *Corporal* has proved to be an amazingly rugged and reliable weapon although relatively complex compared to other field equipment. The troop handling of the toxic propellants has not been the problem that was originally anticipated, although the shipment and storage of those liquids has created several logistical considerations. The determination of ranges and azimuths depends on good maps and survey data which are difficult to obtain in some areas of the world. Longer ranges are more of a problem, and this becomes one of the most important limitations of any ballistic missile system—an area for urgent investigation.

Sergeant is designed to attack targets in the same range category as the *Corporal* but in a much improved tactical manner. It is a solid propellant rocket about 30 feet long and weighs nearly 5 tons. It incorporates an inertial guidance system with more mobile ground equipment. Only a few vehicles are needed for the *Sergeant* weapon in comparison to the *Corporal.* The missile is launched from a combination erector-launching vehicle. The system can be quickly emplaced, fired, and then evacuated rapidly to a new launching site. The use of the solid propellant rocket and inertial guidance system has reduced the maintenance and ground handling procedures as compared to the *Corporal,* while incorporating the tactical advantages of invulnerability to known methods of jamming of the guidance system and speed of action of the mobile equipment. This is a "second generation" missile utilizing the most advanced developments in the technical missile field and the tactical experience gained from *Corporal.* It will be a versatile weapon for any future battlefield.

The newest member of the United States operational ballistic missile family is the *Redstone.* Although well known for its contribution as the first stage of the launching vehicle for the *Explorer* satellite, it is designed primarily as a 200-mile range weapon with a nuclear warhead. In spite of its 70 foot length, 6 foot diameter, and weight of over 30 tons, it is a surprisingly mobile weapon in its tactical role. The missile is transported in three loads along with the associated checkout van and propellant trucks. The launcher is small, mobile, and weighs only 3½ tons. This type of launcher is characteristic of the larger missiles that cannot be transported as an integral part of the launching vehicle.

This *Redstone* tactical rocket of the 40th Field Artillery Missile Group can carry an atomic warhead over distances of up to 200 miles. It now forms part of the arsenal of the U.S. Army's Pentomic divisions.

At the start of the firing sequence, the *Redstone* is assembled and checked out and then erected by an A-frame and truck winch. In the vertical position the propellants, liquid oxygen (lox) and alcohol, are transferred to the missile, and the trajectory information is fed into the inertial guidance system. The launcher is rotated to the target azimuth, and the final countdown begun. As with the *Sergeant,* there is no guidance equipment outside of the missile to monitor. The firing button is pushed, and the missile begins its slow vertical ascent. A few seconds later it gradually pitches toward the target. The inertial guidance system determines the calculated propellant shut-off point, and the missile continues on a free-flight, ballistic trajectory to the target. At a certain point of the trajectory, the warhead separates from the thrust section. Final corrections are made to the warhead's path as it streaks down into the atmosphere at thousands of miles per hour and detonates over the target.

The supply of lox is a significant logistical problem but it has been solved by the development of a lox generating unit that remains close to the firing organization. The large size of the rocket requires careful handling techniques but the number of vehicles necessary to launch this weapon has been held to a minimum. A very definite requirement, again, is accurate map and survey data to locate the launching point with respect to the target.

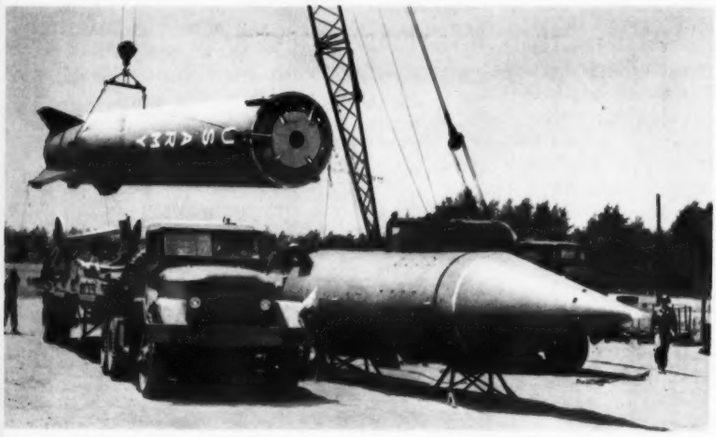
The *Redstone* represents the largest missile system that the United States has placed in a tactically operational status, though the latest missile development for this target category is the *Pershing.* It will be a solid propellant weapon designed to extend the range of the Army missile family. The experience gained from the *Redstone,* new solid propellant tests and advancing missile technology will be incorporated in this new missile, giving it a smaller size, more mobility and yet an increase in range.

Of the weapon systems described, three are fully operational in tactical units: *Honest John, Corporal* and *Redstone.* The remainder —*Dart, Lacrosse, Little John* and *Sergeant*— are expected to be in production soon, with the exception of the *Pershing* which is in the design stage. These missile weapons were designed to operate in the turbulent environment of the tactical *future* battlefield, whatever form it may take. They were developed to meet the threat of a definite target spectrum found from the front lines deep into enemy territory for hundreds of miles. The United States is continuing its research and development toward more effective tactical surface-to-surface weapon systems for greater reliability and lethality in land warfare.

Preparing the Redstone for operation...

The biggest U.S. rocket so far in operational status, the *Redstone* developed by the Army Ballistic Missile Agency is one of the U.S. Army's most important tactical A-weapons. Its jam-proof inertial guidance system and its high re-entry speed make it one of the most lethal weapons in the Western arsenal, against which there appears at the moment to be no defence. The pictures on this page show the main stages in the operation of the rocket, from the final assembly at Chrysler's Detroit plant to its launching by an operational unit in the field.

At Chrysler's Missile Division: finishing touches are being made to a complete *Redstone*. From the factory the complete weapons are transported by air and surface to their destinations.

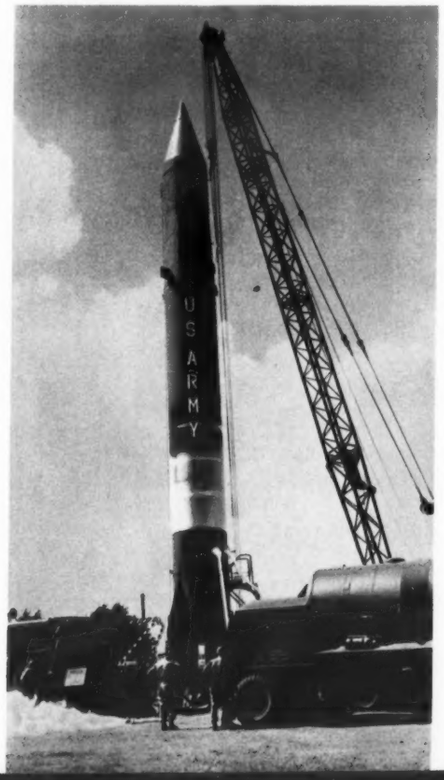


The two fuselage sections—rear portion with rocket motor and propellant tanks, and forward portion with instruments and warhead—are mated in the horizontal position at a 40th Field Artillery Missile Group field depot.

Cables for checking the pneumatic system are connected to a multiple coupling on the launching platform. In the rear a diesel generator to supply current during the launching preparations.

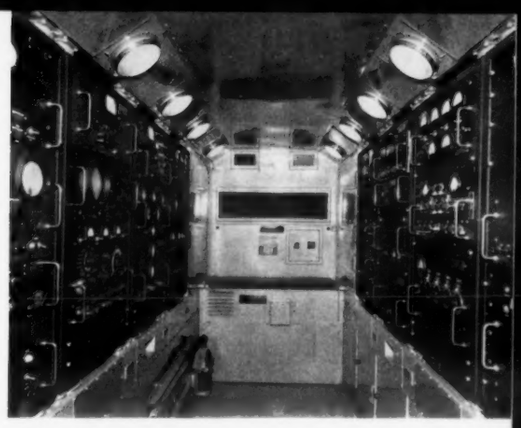
When the 70-foot rocket has been erected by means of an A-frame, the propellants (alcohol and liquid oxygen) are pumped into the tanks, with the oxygen gas formed being eliminated through the overflow tube (left). Safely installed in a foxhole, the crew watch the final stages of the pre-launch testing (right). Then the firing button is pushed, whereupon the cables between the rocket and the power supply are released, and the *Redstone* rises slowly from the ground.

Mechanics check out the rocket engine prior to full testing. On the inner sides of the four cruciform guide vanes can be seen the attachments for the carbon vanes (not yet fitted here). Behind the man sitting inside the thrust chamber are a number of compressed air hoses connecting the pneumatic system with the pre-launch test equipment.

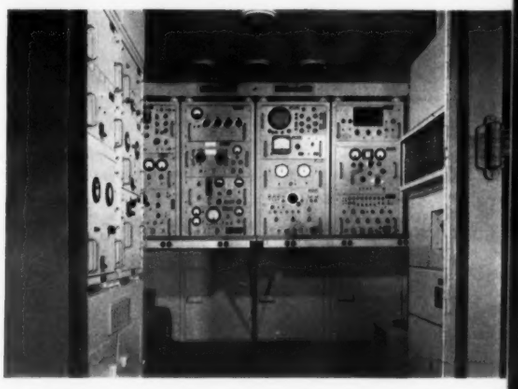


...and the Corporal

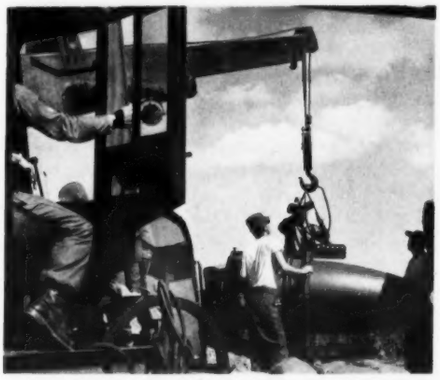
One of the U.S. Army's first rocket weapon systems, the *Corporal* has been in operation with the American forces for several years. Developed by the Jet Propulsion Laboratory (California Institute of Technology) for the Redstone Arsenal, Huntsville, Alabama, the weapon complete with its ground equipment has been produced since 1951 by the Firestone Guided Missile Division, Los Angeles (with guidance and control systems by Gilfillan). The U.S. Army uses the *Corporal* against tactical targets at ranges of up to 75 miles. Each *Corporal* unit is split into three groups (guidance system, fueling and launching group, check-out group), each of which takes up position at a different spot. Working to an exact program, the individual groups prepare the weapon for launching until the warhead is attached, fuel is pumped in, and the rocket is erected and launched.



Considerable importance attaches to the mobile missile test station which enables all components of the *Corporal* guidance system to be checked. A glance inside the functional test centre (above) or the electronic support shop (below) suggests that the launching of a single *Corporal* rocket requires a good dozen electronic specialists.



Immediately after fueling, the *Corporal* is fitted with its atomic warhead (stored separately). The special transporter then takes the rocket to its firing position.



The missile test station is mounted on a standard U.S. Army truck, as is also the firing set (lower picture).

At the launching point the cradle of the transporter swings into the vertical position and sets the complete missile on its launching pad (not shown here).

The *Corporal* rests on its collapsible launching platform, while final adjustments are made to the atomic warhead and guidance system. The special transporter/erector is shown in the left foreground.

Tactical missiles

The Operational Qualities of Tactical Air-to-Surface Missiles

U.S. Navy FJ4B *Fury* carrier-based fighter with a total of five Martin *Bullpup* air-to-surface missiles.

Although unguided rockets for use against ground targets have been in operational service for a great many years, a truly effective, aimed air support for the ground troops without excessive risk to the aircraft can be obtained only with the advent of guided air-to-surface missiles. The Korean war clearly revealed the dangers which jet aircraft pilots faced from enemy machine gun and small arms fire and from their own high speeds. Intensive ground defence often reduced the accuracy of bombing raids on point targets from a shallow dive, or the precision of attacks by means of salvoes of unguided rockets. Added to this were difficulties in piloting the aircraft when broken country made it extremely difficult to maintain the prescribed dive angle and speed during the target approach.

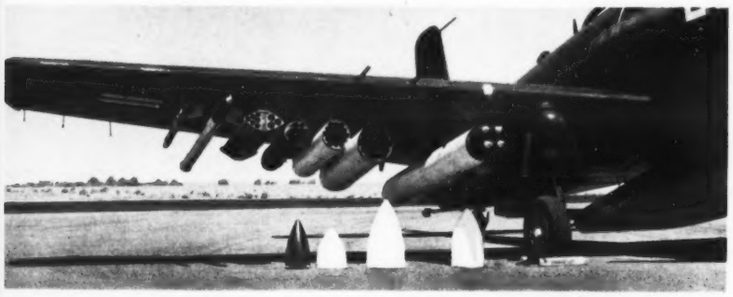
The U.S. Navy therefore decided to develop a guided, winged bomb with rocket propulsion, which would steer towards its target at almost twice the speed of sound and enable the pilot to stay out of the range of enemy ground fire. The winner of the Navy design contest for this kind of air-to-surface missile was the Orlando Division of The Martin Company, who designed a missile 11 ft. in length, with rear-set cruciform wings and control surfaces on the nose. Guidance of the missile after launching is achieved by the pilot by means of a yes-no command signal generator with push buttons for guidance in bearing and elevation. As power unit Martin chose a solid-propellant rocket motor by Allegheny Ballistics Laboratory; and conventional warheads of various dimensions and potential, up to a total weight of 250 lb., can be carried. During the past two years this winged bomb has been developed to operational status under the designation ASM-N-7 *Bullpup*, and is now in production at Martin's Orlando plant. The *Bullpup* is simple in structure and has a high impact accuracy. It requires no pre-launch check-out; once a missile has left the factory it is ready for use. It is divided into three parts—nose containing the guidance system, centre portion carrying the warhead, and tail carrying the propulsion unit—and can be stored for months in dismantled form. When required for use, it is assembled in five minutes by a crew of three and suspended beneath the aircraft wing. The *Bullpup* is now available for service with the U.S. Navy's carrier-borne fighters and fighter-bombers, and a version for the USAF is reportedly in preparation.

A longer-range and considerably more complicated air-to-surface missile is now being developed for the U.S. Navy by Temco Aircraft Corporation. Though no details of the missile, designated *Corvus*, have so far been released, it is reported that it can be carried far into the enemy's hinterland by the Navy's new North American A3J jet aircraft (possibly also by the new F4H and F8U-3 supersonic fighters) and used against heavily defended, tactically vital targets. The *Corvus*, too, will use a solid-propellant rocket unit (made by Reaction Motors Inc.), and its guidance system has been designed by Texas Instrument Co. and W.L. Maxson Corporation. Back in January 1957 Temco confirmed receipt of a Navy development contract valued at $16,000,000. The USAF is also said to be interested in this weapon, though an Air Force spokesman recently expressed doubts on whether the range required by the USAF could be obtained with a solid-propellant motor.—Yet another air-to-surface missile, though in this case not primarily intended for tactical use, is in an advanced development stage at Northrop. This is the *Crossbow*, a self-guided missile with jet propulsion for high subsonic speeds, which automatically steers towards enemy radar installations and destroys them on impact.

This, however, by no means exhausts the USAF'S plans in this important weapons field. Some years ago the Air Research and Development Command was planning a radically new weapon for use by supersonic aircraft against ground targets. The requirement apparently was to release a warhead carrier from very low altitudes and at supersonic speed, and to guide it over terrain obstructions (which serve as cover for the carrier aircraft) to the enemy ground target. It seems that the missile must be ejected from the carrier aircraft by means of a retarding rocket motor firing against the direction of flight. Once the missile is clear, a forward-propulsion rocket motor is ignited, and the missile is guided to the pre-selected target through continuous changes in trajectory by means of a programme control. A weapon system of this category is now under development under the designation *Wag Tail;* main contractor for the overall system is reported to be Minneapolis-Honeywell, of Los Angeles, while the programme guidance system will be supplied by Republic Guided Missile Division. The weapon is reportedly required primarily for fighter-bombers in the Republic F-105 *Thunderchief* class.

To sum up, it seems clear that the increasing speeds of carrier aircraft necessitate increasingly complicated means of delivering warheads to their targets with the required precision. It is therefore understandable that the West's tactical air forces will have to make do with the well-known unguided air-to-surface missiles for some time to come.

The rocket armament of a single navy combat aircraft is equivalent to several salvoes from a small warship's full batteries. The Douglas AD-6 *Skyraider* shown here carries, from left to right under its starboard wing, one 2.75-inch rocket, one *Zuni* rocket, one combined launcher for 2-inch and 2.75-inch rockets, one launcher for seven 2.75-inch rockets, one launcher for 19 rockets of 2-inch calibre and one for nineteen 2.75-inch missiles, and finally one launcher for four *Zuni* rockets.



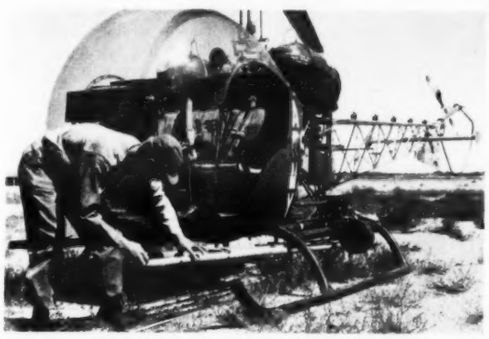
A Martin ASM-N-7 *Bullpup* air-to-surface missile is attached beneath the wing of a FJ 4B fighter-bomber. Following thorough testing of the *Bullpup* by the U.S. Naval Air Missile Test Center, Point Mugu, California, this roughly 600-lb. weapon is now in service with the U.S. Navy and Marine Corps attack squadrons.

A New Mission for Helicopters

Belatedly, though probably not too late, the West's armies have recognized that rotary-wing craft also form excellent firing platforms for rocket weapons. The U.S. Army, in particular, now appears to have whole-heartedly accepted the argument that the helicopter is ideally suited to take over the role of "flying cavalry", as is revealed by the name of Sky Cavalry Platoons, or Sky-Cav for short, given to a new type of helicopter combat unit.

General Howze, Director of Army Aviation in the Office of the Deputy Chief of Staff for Military Operations, has described the Sky-Cav concept as follows: the Army's helicopters will in no sense compete with fighter-bombers, but will serve as highly mobile weapons platforms for small rockets and machine guns, popping up suddenly from behind hills or woods, firing their weapons against tactical targets from a hovering position and then disappearing again equally fast behind their protecting cover. The noise of the rotors would, of course, make it impossible to keep an impending attack entirely secret, but if a number of helicopters were operating simultaneously in an area the enemy would have trouble in predicting the exact attack angle of the individual aircraft. In addition to reconnaissance over enemy-held territory, these armed helicopters would be employed to clean up a given terrain, preparatory to the advance of friendly troops and armoured units. In commenting on a tentative organization chart, General Howze explained that a Sky-Cav (or Aero-Reconnaissance) Company might comprise the following units: two platoons of ten Bell H-13 helicopters, a rifle platoon of two officers and 52 enlisted men, and two platoons of six Bell H-40 weapons helicopters each. Other Army helicopter types besides the Bells have also been tested for their suitability for use with the Sky Cavalry, and the Missiles and Ordnance Systems Division of General Electric has been working on detachable machine gun turrets and rocket launchers which can be fitted to existing helicopters and be remotely controlled from the cockpit.

Judging by the large-scale tests which have been carried out by the U.S. Army Aviation Center at Fort Rucker, the Army is taking its new VTOL fighting force very seriously. In addition to firing missiles, the helicopter will also prove to be an irreplaceable workhorse for the transport of small tactical missiles into the combat zone.



This Bell H-13H two-man helicopter equipped with two 0.3 calibre machine guns and six 2-inch unguided rockets belongs to the 7292nd Aerial Combat Reconnaissance Company stationed at Fort Rucker.

The Sikorsky H-34A transport helicopter has also been converted for ground support duties and is here seen carrying an impressive battery of heavy machine guns and rockets of various calibres.

The new Bell 204 gas turbine helicopter could carry a three-to-four man crew plus up to 2,000 lb. of military load, including several fixed or mobile machine guns and unguided ground attack rockets.

The ground support version of the Vertol H-21C shows eight 80-mm Oerlikon rockets plus four heavy machine guns underneath its fuselage.

A Sikorsky H-37A heavy transport helicopter lifts a several-ton *Honest John* artillery rocket into the combat zone... sets it down, complete with transport trolley, alongside others...

...and a few minutes later the rockets are on their way to a target several miles away.

Fighter Defence Systems

By John A. Airey, de Havilland Propellers Limited, Hatfield

There is a growing tendency to regard fighter interception systems, which are a defence only against conventional manned air attack, as obsolescent. Though it is perhaps not surprising that this view should be widespread at a time when ballistic missile development is occupying an increasing proportion of the world's scientific and technical manpower, it is vital that the fallacy which underlies the argument is appreciated.

It must be recognised that although the Soviet Union has made great strides in ballistic missile techniques, her main strength will continue to lie for many years in her overwhelming superiority in conventional armaments and military manpower. The existence of these vast conventional forces, which comprise over 200 divisions, 20,000 aircraft and some 500 submarines, has forced the West to adopt a deterrent policy which is based on the recognition that massive nuclear bombardment of the sources of power in Russia is the only answer to a large scale Soviet attack.

The role of the deterrent is rapidly being assumed by the ballistic missile with nuclear warhead, which has reached an advanced stage of development on both sides of the Iron Curtain, and the possession of these weapons by both Russia and the United States may well result in an uneasy peace. However, though this situation may well prevent a major war between the Great Powers, it will have the additional effect of releasing Soviet conventional forces for use in perimeter wars in which Russia can claim that she is not directly involved.

In a confused international situation, one thing is certain; so long as Russia maintains her manned bomber force, the West must provide itself with a defence against them. Whether the bomber force would be armed with nuclear weapons in perimeter warfare cannot be forecast with any confidence, and it is clear that a defence force against manned air attack must be based on the assumption that the enemy will use the most effective armament at his disposal.

Defence against manned bombers

Defence against manned air attack must rely on manned fighters or ground-to-air missiles. The latter have several advantages; they have the very high rate of climb desirable if the defence system has limited warning of an enemy attack, they obviate the need for costly airfields and expensively trained pilots, and may require smaller maintenance teams. Manned fighters, however, have the advantage that they can operate at longer range, can patrol or loiter before pressing home the attack, and have an intelligent operator always present to monitor equipment and take vital decisions. They are generally less expensive because they are recoverable. It may well be argued that the ground-to-air missile has an essential role to play in the close defence of areas of special strategic importance, but there can be no doubt that the mobility and flexibility of a manned fighter force is such that it will never be superseded by missiles. The two methods of defence are, and will continue to be, complementary.

Fighter defence

Although there is a clear technical case for the maintenance of a fighter defence force, the cost of modern aircraft is high, and defence needs must be carefully studied in the light of economic resources. For this reason, it is very important to consider the cost of providing and maintaining an adequate fighter force. This is not a subject which can be dealt with adequately in a short article because it must involve many factors depending on the size and location of the area to be defended. Some generalization is, however, possible.

A major factor in the cost must clearly be the number of fighters required. This will determine the cost of providing airfields, pilots, maintenance teams, ground control facilities, etc., all of which comprise the cost of the complete defence system. A study of the number of aircraft required to achieve the necessary degree of defence is, therefore, a first step towards an estimate of the cost of the system as a whole; indeed, the total cost should be approximately proportional to the number of fighters.

Number of fighters required

The number of fighters required to achieve the destruction of a certain percentage of an enemy raid depends on two factors:

Standard armament of the D.H. *Sea Vixen* twin-jet all-weather fighter: four D.H. *Firestreak* air-to-air missiles with infrared homing head.

1. the probability that the fighter can be placed in the vicinity of the target in a position where its armament can be fired; and
2. the probability that the armament, fired correctly, will destroy the target.

The probability of interception may vary considerably depending upon ground control facilities, the type of interception radar carried by the fighter and the use of radar countermeasures by the enemy. The probability that the armament will destroy the target depends upon whether or not it is automatically guided, on the size of the warhead and on its fuse design. If, however, tentative values are assigned to these probabilities, it is a simple matter to assess the number of fighters required if the aim of the defence system is, for example, to destroy 45 enemy bombers out of a raid of 50. If each fighter costs £200,000 the cost of the fighters required to perform this task is shown in the diagram. This diagram clearly illustrates the saving in the cost of aircraft if the probability of interception and lethality of the armament are raised to their highest possible value. For example, suppose the probability that a visual attack fighter can be brought into the small firing zones associated with guns or unguided rockets, on the accurate firing course necessary in the case of such armament, is 50 percent, and the lethality of this type of armament is 30 percent; then 710 aircraft costing £142 million will be required. If the fighters are equipped with radar aids which increase the probability of interception to 65 percent, the number of fighters is reduced to 520 and the cost to £104 million.

The installation of air-to-air guided weapons on the fighters greatly improves the picture both because of their higher lethality and because of their wider firing zones and greater aiming tolerances. For example, if the visual attack fighters are equipped with two guided weapons each of 80 percent lethality (so that the probability of one or other missile destroying the target is 96 percent) and the wider firing zones of these weapons increases the chance of interception to 60 percent, the number of aircraft is reduced to 140 and the cost to £28 million. The introduction of both A. I. and effective guided weapons might increase probabilities of interception and kill to 80 percent and 96 percent respectively, so that the aircraft required will number 79 and the cost of these aircraft will be £15.8 million.

It is not claimed that these figures are accurate but they do serve to illustrate the point that as the fighters become more sophisticated and their armament more effective, the number required is very considerably

English Electric P.1B supersonic all-weather fighter with a *Firestreak* air-to-air missile on either side of the fuselage.

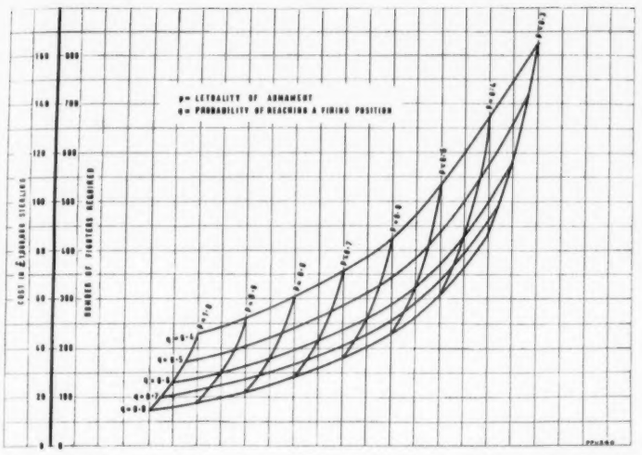
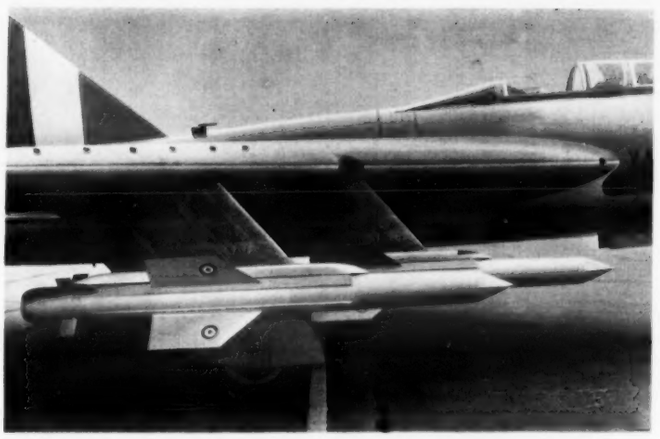


Diagram: Total costs and number of fighters (ordinates) required to shoot down 45 bombers out of a formation of 50. The curves show how these values depend on the lethality of the aircraft's armament p and the probability q of the fighter's intercepting the bomber.



The Gloster *Javelin's* standard armament also comprises four *Firestreaks*, which are carried beneath the wings on long pylons with enclosed guide rails.

reduced. In fact, the reduction in the number of aircraft will be found to more than outweigh the added cost of the radar and guided weapons, particularly when it is remembered that the fewer the operational aircraft, the smaller will be the requirement for spares, aircraft maintenance, pilots, airfields and ground control facilities.

The armament

The diagram clearly indicates not only that effective guided weapon armament is an economic necessity in a modern fighter defence force; it also shows that the most lethal armament that can be chosen will be the most economic. The only circumstances in which this general rule is likely to prove untrue is when an adequate modern fighter force with the ground facilities to operate and control it is already in being. Thus, for example, the American air-to-air weapon *Sidewinder*, which was designed with a view to simplicity and cheapness, can be justified for the defence of America. On the other hand, more sophisticated weapons such as the British *Firestreak* or the American *Sparrow* will prove to be more economic to any country faced with the problem of modernizing its fighter force, particularly if the purchase of new aircraft is involved.

It is important to note the fallacy in an argument which is often raised. It is claimed that a fighter armament of four simple weapons, each with a lethality of 50 percent (so that the probability that one of the four will destroy the target is about 94 percent) may be cheaper than, and is almost as effective as, two weapons, each with 80 percent lethality (which means that the chance that one or other will kill the target is 96 percent). This argument is quite false if the lower lethality of the cheaper weapon is in any way due to the environment at the time of firing. For example, if cheapness and simplicity were to be achieved by eliminating a heating or cooling system, or some other refinement which is required only in certain firing conditions, and if one weapon fails from this cause, there is no reason to suppose that the other three weapons, which will be fired in a similar environment, will be more successful. The argument is therefore valid only if the possible causes of failure are completely random and never due to a fundamental limitation of the missile.

Thus although high lethality may well involve sophistication and increased cost of the missiles themselves, it will result in a decrease in the cost of the defence system as a whole, except in very specia cases.

Conclusion

So long as the potential enemy maintains a large force of bomber aircraft, an adequate system of defence against it is essential. Ground-to-air guided weapons may have an essential role in the close defence of small areas of special strategic importance but they can never be more than complementary to a mobile force of manned aircraft. It is clearly essential that the cost of maintaining this force be kept as low as possible by reducing the number of aircraft and the facilities required for their support. This can be done by increasing the effectiveness of each fighter by providing it with suitable interception radar and guided weapon armament of the highest possible lethality.

A Hawker *Hunter* interceptor takes off on a practice mission, with a Fairey *Fireflash* air-to-air missile under each wing.

The West's Air-to-Air Missiles

Type	Manufacturer	Country	Propulsion unit	Guidance	Length (ft.)	Launching weight (lb.)	Max. Mach number	Status	Remarks
Falcon 1D	Hughes Aircraft	USA	Solid-propellant rocket	Semi-active radar homing	6.5′	110 lb.	~2.5	Operational	Range approx. 5 miles
Falcon 2A	Hughes Aircraft	USA	Solid-propellant rocket	Infrared homing	6.5′	120 lb.	~2.5	Operational	Range approx. 5 miles
Sparrow I	Sperry Gyroscope	USA	Solid-propellant rocket	Beam guidance + semi-active radar homing	12.5′	295 lb.	2.5+	Operational	Range approx. 5 miles
Sparrow III	Raytheon Manufacturing	USA	Solid-propellant rocket	Active radar homing	12.0′	350 lb.	~3.0	Operational testing	Range more than 7 miles
Sidewinder	Philco Corp. + General Electric	USA	Solid-propellant rocket	Infrared homing	9.5′	155 lb.	2.5	Operational	Range 4–6 miles; advanced Diamondback under test
Genie	Douglas Aircraft	USA	Solid-propellant rocket	Unguided	~8.0′	~1,000 lb.	1.5+	Operational	Atomic warhead; range approx. 2 miles
Fireflash	Fairey Aviation	Great Britain	Solid-propellant booster	Beam guidance	7.4′	–	2.0	Operational	Length without booster
Firestreak	De Havilland	Great Britain	Solid-propellant rocket	Infrared homing	10.5′	~330 lb.	–	Operational testing	–
Matra R.510	Société Matra	France	Solid-propellant rocket	Optical homing	10.5′	375 lb.	2.0	In production	Range approx. 5 miles
Nord 5103	Nord-Aviation	France	Solid-propellant rocket	Command guidance	8.25′	287 lb.	1.7	Operational testing	Range 2½–3 miles

Grumman F9F-8 *Cougar* naval single-seat fighter with four Philco/General Electric *Sidewinder* air-to-air missiles, as used for example by the carrier-borne fighters of the 7th U.S. Fleet in the Far East.

American Air-to-Air Missile Development

In order to increase the fighting power and flexibility of its fighter force, the United States began many years ago to arm its fighters with unguided and guided air-to-air missiles for use against bombers. Initially unguided, fin-stabilized rockets of 2.75 and 5-inch calibre were used. These were fired in salvoes and were specially suitable for attacks on a lead course. Rockets of this kind were for years standard armament on the F-86D, F-89D and F-94C all-weather fighters, which until very recently were responsible for the defence of the United States. They were later followed by the first guided missiles of the GAR-1D *Falcon* and AAM-N-2 *Sparrow I* types, which were designed primarily for the USAF's F-89H, F-101B and F-102A fighters and the Navy's F7U *Cutlass* and F3H *Demon*. Both weapons were radar-guided, with speeds of above Mach 2.5 and operational ranges of between 4 and 5 miles. The *Falcon I* had a semi-active radar homing head, the *Sparrow I* a radar beam guidance system for the first flight phase and a semi-active radar homing head for pursuit.

These two weapons have been in service with the USAF and the Navy in thousands since 1955. Later, Hughes, the development company for the *Falcon I*, tested a new infrared homing system, capable of locking on to the target from a greater range and within a larger angle than the GAR-1D. This infrared system was then fitted in the improved GAR-2A *Falcon II*, which can be fired against its target not only from the rear, but also from the side or in a steep angle from below. As the high sensitivity of the infrared equipment makes it difficult to pursue the target accurately under certain atmospheric conditions (heavy clouds or rain), USAF fighters as a rule carry a "mixed" rocket armament consisting of *Falcon I* and *Falcon II*. They then fire one or both, depending on operational conditions. In this way a hit probability of 90 percent is reportedly obtained.

Whereas the guided missiles so far mentioned are relatively complicated and hence costly weapons (a single missile of the *Falcon* series costs from $12,000 to $19,000), the AAM-N-7 *Sidewinder* developed by the Naval Ordnance Test Station, China Lake, is a rugged and very simple air-to-air missile which incorporates a bare dozen moving parts and whose electronic equipment is hardly more extensive than an ordinary radio set. The pencil-shaped rocket is today in production at Philco and General Electric. Like the GAR-2A, the *Sidewinder* steers towards the target with the aid of an infrared homing head (General Electric), which at higher altitudes is effective over ranges of roughly 2 miles; the actual operational range of the weapon is 6 to 7 miles, and its maximum speed in the region of Mach 2.5. Although the guidance system works extremely accurately, and the *Sidewinder* is said to operate at angular accelerations of up to 14 g, the accuracy of the infrared homing system will depend on atmospheric conditions and may not be entirely satisfactory in heavy cloud. However, this weakness appears to be inherent in all homing systems using infrared rays and somewhat counteracts the advantages which these systems offer under good atmospheric conditions in locking on to heat-producing targets. Nevertheless the U.S. Navy and more recently the USAF have received a large number of *Sidewinders* (designated GAR-8 in the USAF), which greatly help to increase the firepower of supersonic fighters. At present the *Sidewinder* arms the F9F, F11F and F-104A.

An air-to-air missile of very new design is being built by Raytheon Manufacturing Co. for the U.S. Navy. This is the AAM-N-6 *Sparrow III*,

The U.S. Navy's F3H-2M supersonic fighter armed with four *Sparrow I* missiles.

A Raytheon *Sparrow III* air-to-air missile with active radar homing system beneath the wing of a F3H *Demon*.

The GAR-2A *Falcon* air-to-air missile with infrared homing is standard armament on the USAF's F-102A fighter.

The GAR-1D radar-guided air-to-air weapon (right) and its successor, the GAR-3 *Falcon III* with larger wings and ceramic nose cone.

F9F-8 naval fighters are loaded with *Sidewinder* rockets ready for take-off.

The *Sparrow II* rocket developed by Douglas is now being produced under licence in Canada and is used with the Avro CF-100 Mk.5M (picture) and CF-105 *Arrow* all-weather fighters.

a rocket equipped with a fully-active radar homing system, which is reported to reach its target in all weathers and despite rapid evasive manoeuvres by the enemy. It attains a speed corresponding to Mach 3, so that the air masses provoke serious heating of the airframe and the temperature-sensitive portions of the guidance system and the warhead, particularly in turns—a problem which also arises in the latest version of the *Falcon* (GAR-3), where it has led to the use of a ceramic nose cone. The body of the *Sparrow III* has been derived from that of the earlier *Sparrow II* developed by Douglas. Its ruggedness combined with low weight plays a decisive part in improving the precision and range of the new missile.

In 1956, a few months after the testing of the first atomic warhead for air-to-air missiles, Douglas began on the design of a small, compact weapon intended to carry an atomic warhead into the vicinity of an enemy air target. The first MB-1 *Genie* was successfully tested aboard a F-89D as early as 1957, and although this weapon is unguided the test confirmed the value of this radical means of defence. Thereupon several long-range *Voodoo* fighters were modified to take two *Genies* each, rapid preparations were made for production of the new rocket, and its development into a guided missile immediately tackled. Recently North American announced that the new F-108 long-range fighter will also be armed with an atomic-warhead air-to-air missile (designation GAR-9), said to be vastly superior in performance to the MB-1. Reportedly this weapon, developed by Hughes, will be operational by 1960.

First picture of the Douglas MB-1 *Genie* air-to-air rocket with atomic warhead.

*

It is still too early to say with certainty what direction American air-to-air rocket development will follow in the future. The newest missiles in the present U.S. arsenal, the development of a larger and more complicated *Sidewinder* successor (project designation *Diamondback*) and work on a project for an air-to-air missile with a range of more than 60 miles (project designation *Eagle*) all suggest that airborne missiles for use against bombers will become increasingly big and complex and that only supersonic fighters in the weight class of the F-108 or the Canadian CF-105 will be able to use them.

Winged Tank-Busters

The main weapons of mobile warfare on the ground—tanks, armoured cars and armoured artillery—have in recent years come up against a new and dangerous opponent, in the shape of the guided anti-tank missile fired by a single infantryman in full cover.

Armies pretty well throughout the world today have dwarf missiles of this category at least in the operational testing stage, if not already in full operational service with the units. They are designed to extend the range of the older anti-tank weapons (rifle grenades, "bazookas" and anti-tank guns) and at the same time—thanks to accurate guidance systems and powerful warheads—to obtain a *very high "kill" probability*. All are fitted with cruciform wings and powered by a solid-propellant charge. Depending on their size, they are launched from the ground (Contraves-Oerlikon rocket with auxiliary support), direct from their transport container (Vickers 891 and Nord SS.10) or from tubular rigs and guide rails mounted on cross-country vehicles. A number of SS.10s have also been launched experimentally from helicopters and slow-flying aircraft. Maximum combat range is usually 1,760 yards, or in exceptional cases 2,200 yards or more; full guidance is often obtained after a distance of only 50 yards.

All the weapons shown here are steered to their targets (often rapidly moving targets) by means of continuous wire command guidance once the missile is in flight. Steering commands are transmitted to the rocket via a thin multiple telephone cable which unwinds from the rocket and is attached at the other end to the operator's control unit. The wings are equipped with either vibrating spoilers (so-called yes-no control) or with normal trailing edge control surfaces. In addition, one or more gyros, rotated by powder charges, are fitted, either to stabilize the weapon's attitude from launching to impact, or—if the weapon itself is rotated in flight—to ensure stabilization of a converter drum. The object of the latter is to distribute the controller's commands, based on surface coordinates, to those control elements of the rotating rocket which are in the correct position in space at any given moment.

Two Contraves-Oerlikon *Moskito* anti-tank rockets and their operator with control unit (hanging from a strap) form a combat unit. The operator carries the two *Moskitos*, dismantled, in a single container to the launching point, mounts the wings, aims the rockets on their supports towards the enemy, lays the terminal plug for the multiple cable to hand and takes cover (full description in *Interavia* No. 7, 1958).

The Nord SS.10 operational anti-tank missile is launched from a simple steel tube rig. The weapon's transport container need not be removed.

Launching a Vickers 891 direct from the container set up on the ground: the container's lid and two spikes driven into the ground serve as supports; guidance is by means of wire commands transmitted from the miniature joystick.

A battery of seven Nord SS.11 swept-wing anti-tank rockets (successor to the SS.10) on a jeep; the control post is in the driver's seat, with sighting rearwards.

The most suitable equipment for transmitting the operator's commands has proved to be the miniature "joystick" which is manipulated in the same way as the control column of a sports aircraft and gives the rocket "fly higher/fly lower," or left/right signals. In most cases sighting is done either by the naked eye or by means of binoculars, though the operator must have good judgment and anticipation ability, not to mention adequate practice. Only the launching vehicles for the relatively costly *Dart* weapon system carry telescopic sights and electronic lead calculators, which relieve the operator of a good part of the anticipation work. The telescopic sight shows not only the moving target but also the rocket symbol provided by the calculator, so that all the operator has to do is to keep the two images superimposed by means of the joystick in order to score a certain hit.

The following table gives the principal data for the seven types of anti-tank missile so far known:

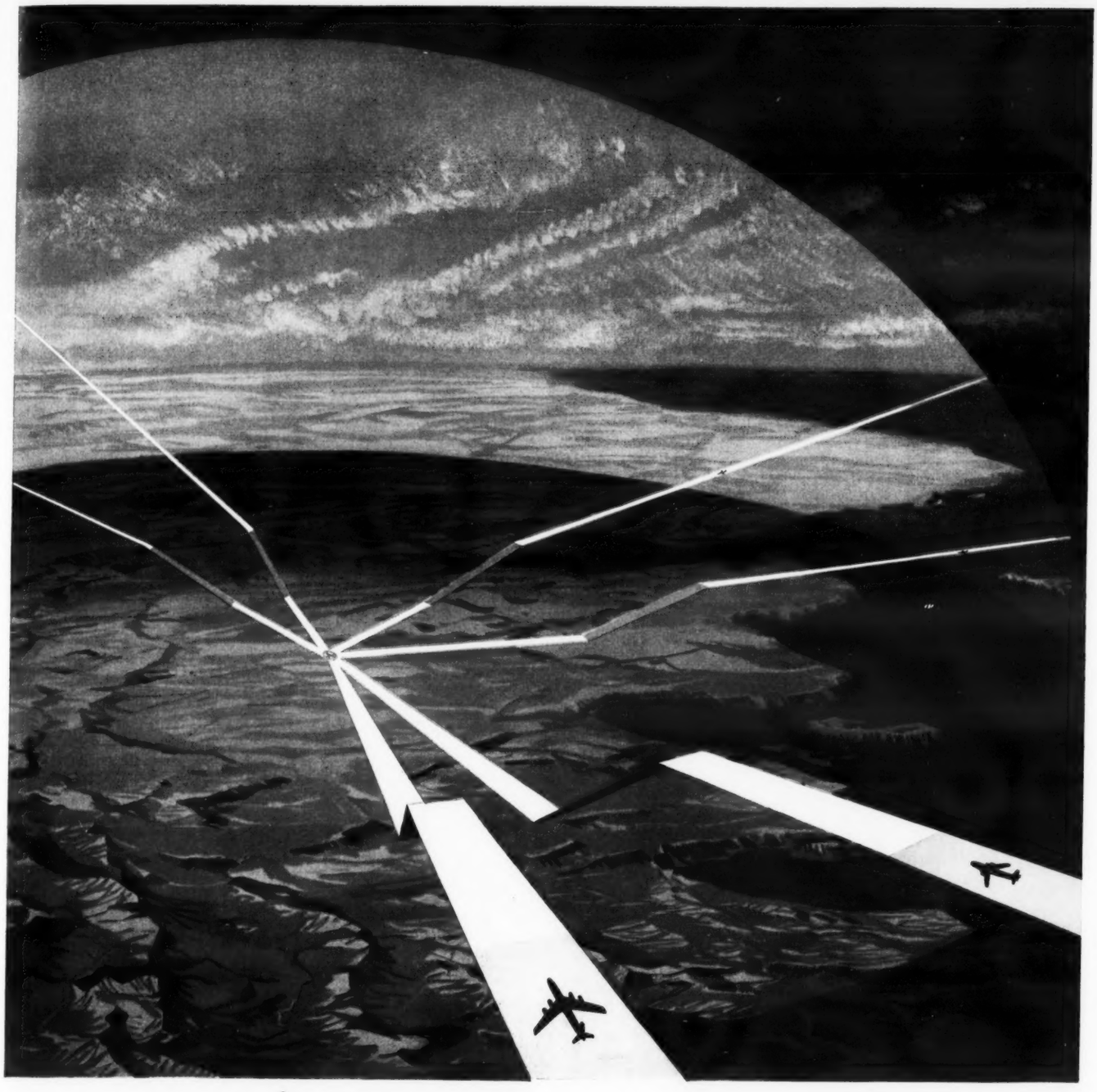
Manufacturer and Type Designation	Length (inches)	Span (inches)	Take-off weight (lb.)	Max. speed (m/sec)
Contraves-Oerlikon *Moskito* (Switzerland)	36.6	23.6	23	~ 85
Nord-Aviation SS.10 (France)	34	29.5	~ 33	~ 85
Nord-Aviation SS.11 (France)	~ 48	~ 27	~ 40	~ 200
Vickers-Armstrongs Type 891 (Great Britain)	33	11	40*	—
Pye Ltd. Short-range G.M. (Great Britain)	60	24	—	—
Aerophysics Development Corporation *Dart* (SSM-A-23) (USA)	60	~ 42	~ 100	~ 280
Government Aircraft Factory *Malkara* (Australia)	~ 72	—	~ 200	~ 110

* Including containers for transport and launching of the weapon.

The U.S. Army's *Dart* on its launching rig mounted on a jeep or truck: cruciform wings with trailing edge control surfaces and spoilers on the cruciform tail vanes.

With a length of around 6 ft., the Australian *Malkara* now undergoing operational testing is the biggest of all known anti-tank missiles.

Prototype of the Pye "short-range guided missile" on its launching rig.



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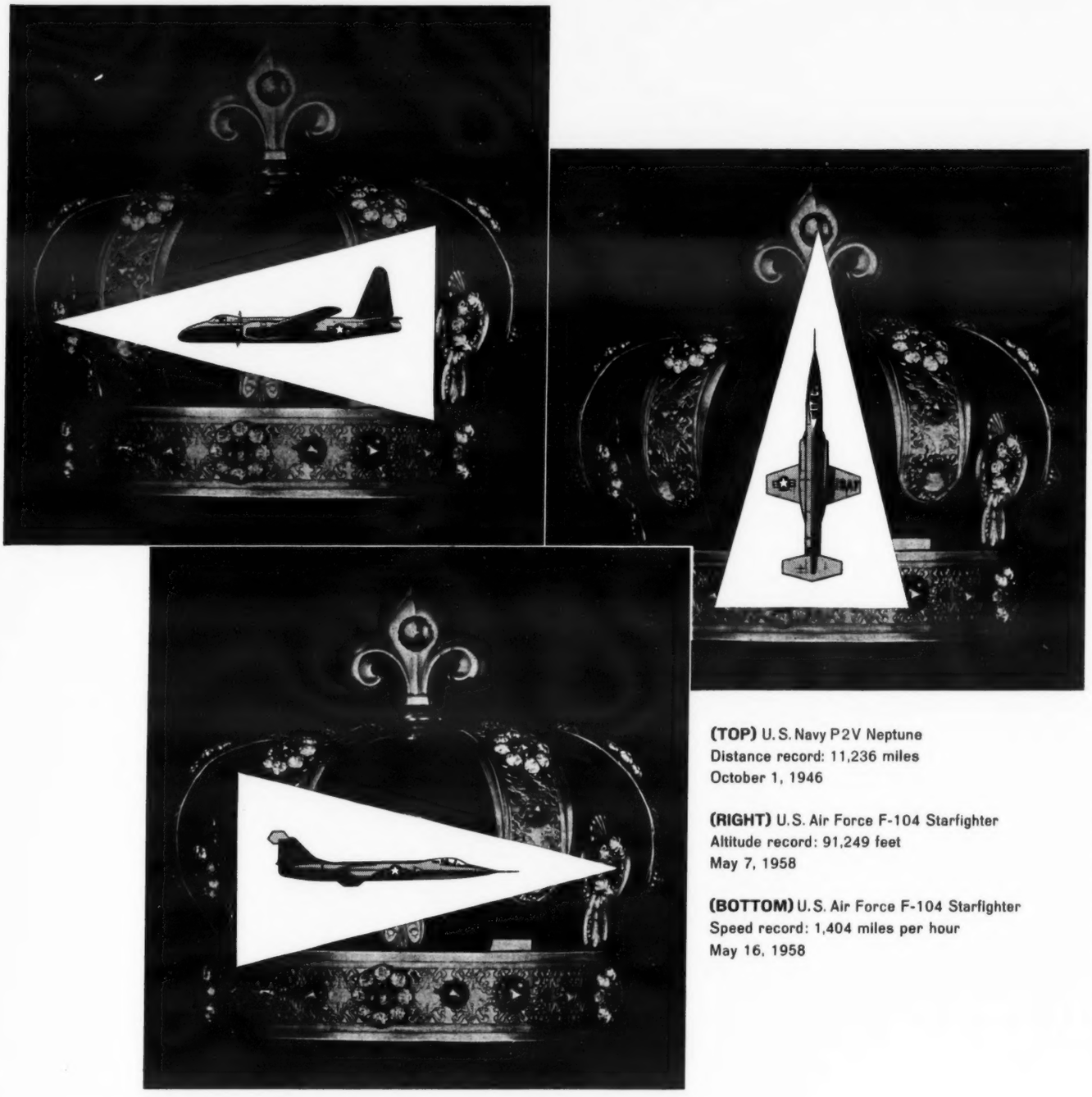

(TOP) U.S. Navy P2V Neptune
Distance record: 11,236 miles
October 1, 1946

(RIGHT) U.S. Air Force F-104 Starfighter
Altitude record: 91,249 feet
May 7, 1958

(BOTTOM) U.S. Air Force F-104 Starfighter
Speed record: 1,404 miles per hour
May 16, 1958

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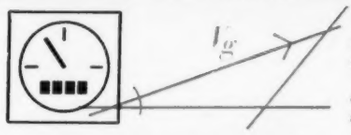

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Permanently at the ready: a U.S. Army battery of *Nike Ajax* anti-aircraft rockets.

The most effective defense against the threat of aerial attack is the guided missile weapon system. This is emphasized at shorter ranges when response time is limited and the targets fly at the high subsonic velocities of today's aircraft and missiles. The United States Army has developed a family of tactical guided missiles to counter this threat to the vital industrial and population centers of the Continental United States and to its military forces deployed in other areas of the Free World.

These anti-air missile systems are designed to attack three kinds of targets that constitute the aerial threat. The first target is the manned or unmanned aircraft that may use a conventional reciprocating engine, a turbojet engine, or a rocket engine. These aircraft may fly at speeds from below the speed of sound to several times the speed of sound. Their altitudes can vary from almost ground level up to about 80,000 feet, for the "air breathing" engines. The rocket-powered planes have no altitude limitation but they will have to penetrate the atmosphere in order to attack a land target accurately. This category of targets also includes the "cruise missile" that could be launched from submarines or Polar land bases. The second target is the air-to-surface missile that is launched from an aircraft at a "stand-off" distance from a defended area. This method of attack may give the aircraft protection from defense weapons and subjects only the unmanned missile to the hazard of being destroyed in flight. The missile, in this case, can be turbojet, ramjet, or rocket-propelled. The last type of target is the ballistic missile with its well-known characteristics of unusually high Mach numbers, small radar cross-section, and . . . predictable trajectory.

The present Army weapon systems that have been developed to counter the aircraft and air-to-surface missile threats are the *Nike Ajax, Nike Hercules,* and *Hawk*. *Nike Ajax* and *Nike Hercules* are operational and integrated into the air defense of the United States.

The *Hawk* missile system is now under systems test and is expected to be operational soon. It will complement the *Nike Ajax* and *Hercules* by adding an extremely low altitude capability to the defense. The defense against the ballistic missile will be met by *Nike Zeus* and *Plato*. Both are in the system development stage. *Nike Zeus* is planned for continental U.S. employment, while *Plato* will give Army forces in the field an anti-ballistic missile capability.

As part of the North American Air Defense Command, the Army has the mission of defending cities and areas that can be protected by missile units which receive their guidance information from radars located near the launching site. These same requirements also extend to the Army forces employed in a theater of operations where the air protection of the troops on the battlefield is important to success in combat.

The organizations that fire these missiles are based on conventional artillery battalion structure. There are normally four firing batteries in a battalion, and each of these batteries will be well separated from the others. A battery is essentially an autonomous missile system; that is, it contains all of the necessary detection and acquisition elements plus the firing elements to attack airborne targets. It is capable of immediate engagement at any time. However, the battery can be on a lower alert status if long-range, "early" warning is provided. This means that full crews do not constantly man the equipment, and the electronic gear is not maintained on full power all of the time.

Transmitter equipment for a *Nike Ajax* battery.

The responsibility for early warning in the United States belongs to air defense collective means such as the Semi-Automatic Ground Environment (SAGE) system that reaches out with the long-range radars of the Distant Early Warning (DEW) line and sends this detection information to an operations center where the "Missile Master" is located. The Missile Master is a complete system for coordinating and directing a large number of missile firing batteries. It collects information from the SAGE system and other agencies on the location and identity of aircraft or missiles, presents the data on electronic screens, and distributes it to the firing batteries—all within fractions of a second. Each battery receives a continuous flow of fresh data on all targets within the defense areas. From this the battery commander can make the proper selection of the target to be attacked.

The *Nike Ajax* guided missile system was the first to become operational in the air defense network. The system consists of a two-stage rocket, three radars, an electronic computer, and the necessary control and communications equipment.—The missile itself, actually the second stage of a booster-missile combination, is a liquid-propellant rocket about 20 feet long and 1 foot in diameter. The missile is launched at the near vertical by the solid propellant booster. The

A *Nike* launcher site of the 740th AAA Missile Battalion at Fort Winfield Scott.

Successor to the *Nike Ajax* is the *Nike Hercules*, also in operational service, with longer range and atomic warhead.

booster drops off in a few seconds after which the missile's rocket engine begins operation. Then the missile goes through a steep turn to an "on-course" trajectory. After the propulsive force ceases, the missile coasts to the target at supersonic speeds. The overall trajectory is such as to maintain a speed and maneuverability advantage over the target throughout the engagement. The missile is under the control of its guidance system from the end of boost until intercept.

The radars and the computer form the basic components of the ground guidance equipment for the *Ajax* command guidance system. One radar is for acquisition of targets, the second tracks the missile, and the third tracks the target. Information from the last two radars is fed to the computer concerning the position and velocity of both the target and the missile. Signals are then sent to the fins to move them in the correct direction and amount for a target "kill". Any evasive action by the target is detected by the target-tracking radar, and this information is sent to the computer. The computer re-evaluates the trajectory of the missile to meet the change of direction, and instantaneous steering signals are sent to the missile to correct its course.

Nike Hercules is the second missile of the *Nike* family to become operational. It has the same basic elements as *Ajax* but it goes higher and faster and carries an atomic warhead. *Nike Hercules* uses a solid propellant sustainer engine and a solid propellant booster. The solid propellant of the missile and booster simplifies the checkout preparations and logistics operations, a major advantage over the liquid rocket engine. The missile has a range greater than *Nike Ajax*, and can destroy the first two categories of targets. The *Hercules* system incorporates many new features that have resulted in an outstanding performance of its air defense mission. It has "killed" 23 out of 27 drone targets in the last few months for a reliability of 85 percent. Recently, a *Hercules* firing unit traveled over 1,000 miles by truck, set up the equipment and fired six missiles, all successful kills, at high-speed jet targets. This demonstration illustrates the mobility and reliability that anti-air weapons need when used with combat forces in the field.

The *Hawk* (left), developed and built by Raytheon, is designed for use against low-flying raiders and can be launched from either fixed installations or by mobile troop units. Its fire-control radar (right) automatically tracks the target and eliminates all radar echoes from trees, houses or hills which make ordinary radar "blind".

Hawk is the third guided missile that will be used in the fixed installations in the Continental United States as well as with the infantry at the front lines. It is the most mobile of the systems that have been mentioned and will move with the Army forces in any battle area. Its low altitude capability has already been proven in tests when it destroyed targets at less than 100 feet in altitude. The *Hawk* uses a simplified launcher and a new lightweight radar system. The launcher is mounted as a two-wheeled, towed load that can be quickly emplaced and trained in azimuth and elevation for immediate action.

Nike Zeus is being designed and developed to counter the ballistic missile or any similar threat. Since this type of target may travel at very high supersonic speeds, acquisition radars must be as far as practicable from the *Nike Zeus* launching site.

On the early warning system detects a target, then the system must function automatically. On the radar scope any "blip" might be an ICBM. As a result, it will be difficult to keep a 24 hour, 7 days a week alert where 10 minutes can make a vital difference. Thus, the defense against the ballistic missile requires a missile system that can detect, acquire and engage the nose cone with a minimum of delay. *Nike Zeus* is such an autonomous system. Like the first two operational members of the *Nike* family, *Zeus* also utilizes early warning information to permit a relatively lower alert status.

Plato will meet the requirement for battlefield defense against the short-range ballistic missile. This type of weapon is a real threat to the combat forces on land because the defense reaction time is so short. *Plato* will use many components of the *Zeus* system to include the missile and some of the ground equipment. The result will be a highly mobile anti-ballistic missile system that can be emplaced and evacuated from an area as the tactical situation requires.

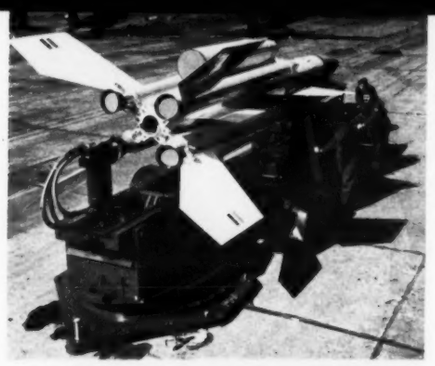
This giant Thiokol solid-propellant rocket motor with a thrust of several hundred thousand pounds will carry an undisclosed surface-to-air missile to great altitudes within seconds. It is rumoured to be the first stage of the U.S. Army's *Zeus* anti-ICBM missile.

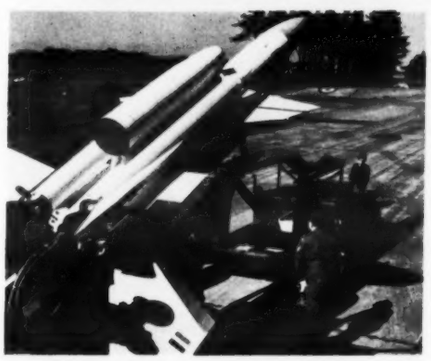
No firing tests can ever faithfully reproduce the environment of defensive aerial combat, but *Nike Ajax*, *Nike Hercules* and *Hawk* have demonstrated the capability of destroying high speed jet targets in an amazing variety of altitudes and ranges. These are not missiles but missile *systems* and as such they contain an extensive amount of electronic and electrical gear. Maintenance, calibration and continual checking of the equipment is necessary to insure tactical reliability. The soldier-operators must be kept in a high state of training and alertness for considerable periods of time. These problems are common to all of these systems and they have been studied and evaluated for a number of years since the first *Nike Ajax* battalion actively entered U.S. air defense commands.

Bloodhound

The British Operational Weapon System for Air Defence

By D. Rowley, Deputy Chief Designer, Guided Weapons Division, Bristol Aircraft Limited





Preparing a Bristol-Ferranti *Bloodhound* for action: the missile is driven to the firing site on a transport and loading vehicle and placed on the launcher. Next the power supply cables are plugged into the rear of the missile, and the launcher is erected. The missile is now ready to fire.

It is often said that the cost of a guided missile defence is too high, presumably because each missile can fly only once. What is forgotten is that under wartime conditions, the fighter may only fly on two or three operational missions. And what is the value of a second flight if your power to retaliate has already disappeared in a thermo-nuclear holocaust?—*Bloodhound* provides a good solution to the air defence problem because of its high lethality, its low cost per target destroyed (the true measure of economy) and low peacetime training and running cost, when compared with any other defence.

The Bristol-Ferranti *Bloodhound* was designed primarily for the defence of the United Kingdom and is soon to go into service as the first defender of the nuclear deterrent. Because of the threat of mass air attacks, well known in Europe, and because of the enormous power of a single nuclear bomb, the overriding requirements were high firepower, and a high probability of immediate destruction of the attacking aircraft.—The high firepower is obtained by the use of semi-active homing. One radar illuminates each target, or small group of targets if they are in close formation. The missile receives no instructions from the ground after launch, but decides its own course by watching the radar reflections from the target. Consequently, any desired number of missiles can be flown against the one target or formation, using only one radar. Against single targets a small salvo could be fired, sufficient to leave the target only a very small chance of escaping. If he should escape, a second salvo would make sure. In the case of a tight formation a similar approach using more missiles will give him the same negligible chance of success.

The complementary requirements for high accuracy and lethality are met by the use of the moving wing monoplane, which was chosen after careful study of the possible alternatives and the problems of homing interceptions. Because of the large ailerons (the whole wing is used) *Bloodhound* is able to roll to change its direction of manoeuvre very quickly even at the highest altitudes. The body always remains at small incidences, and lift is obtained by turning the wings to incidence. Consequently, the delays associated with pitching the body at very high altitudes are avoided. One of the biggest problems of the homing missile designer is concerned with spurious demands for manoeuvre arising from the effect of body angular motion on the sensitive receiver system, and this usually defines the operational ceiling. Because the *Bloodhound* body remains at small incidence this problem is not of great significance, and this might well define the operation ceiling.

Bloodhound was also designed with considerable development potential to meet advances in the threat and to give many years of useful operational life. This led to the characteristics already mentioned and to the use of ramjets.—This means that with changes of the same extent as are almost always applied to military aircraft, *Bloodhound* could for many years to come continue in its role of providing a high firepower, high lethality defence which would make very remote the enemy's chance of achieving his objective by airborne means.

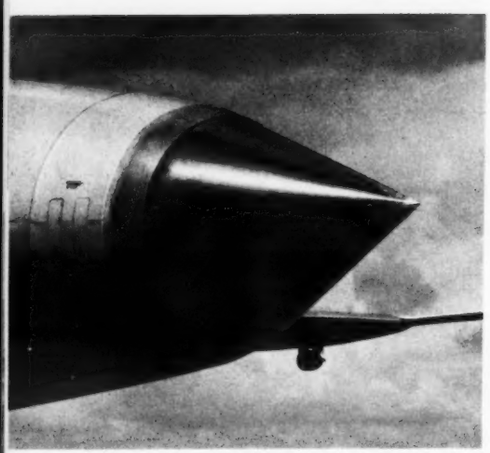
Surface-to-Air Missiles

Key: GBR = Great Britain; FRN = France; SWI = Switzerland; SP = solid propellant; LP = liquid propellant; Ch.W = chemical warhead; At.W = atomic warhead

Missile category	Designation	Manufacturer	Country	Propulsion	Guidance system	Warhead	Length/ Length with booster (ft.)	Take-off weight (incl. booster) (lb.)	Max. Mach no.	Operational range (miles)	Status
1. Short and medium-range anti-aircraft and anti-missile missiles	SAM-A-7 Nike Ajax	Western Electric/ Douglas	USA	SP booster + LP rocket	Radio command + beam follow-up	Ch. W	19.8′ 35.5′	2,000+	2.3	25	Operational
	XM3 Hawk	Raytheon	USA	2-stage SP rocket	Semi-active radar homing	Ch. W	16.8′	1,200	2.8+	15	Operational testing, in production
	SAM-N-7 Terrier I	Convair	USA	SP booster + SP rocket	Beam	Ch. W	14.8′ 26.5′	~1,500	2.5	10-11	Operational
	Tartar	Convair	USA	SP rocket	Beam + semi-active radar homing	Ch. W	~13′	~600	~2.5	~12.5	Operational testing
	Bloodhound	Bristol/Ferranti	GBR	4 SP boosters + 2 ramjets	Semi-active radar homing	Ch. W	22.2′ 25.2′	3,000+	~2.2	–	Operational
	Thunderbird	English Electric	GBR	4 SP boosters + SP rocket	Semi-active radar homing	Ch. W	18.9′	~1,500	~2	~25	Operational testing, in production
	Seaslug	Short	GBR	4 SP boosters + SP rocket	Beam	Ch. W	~20′	–	–	–	Operational testing, in production
	Parca	DEFA	FRN	4 SP boosters + LP rocket	Radio command	Ch. W	16.7′ 18.0′	2,200	'.7	~21	In production
	Oerlikon 56D	Contraves	SWI	LP rocket	Beam	Ch. W	19.7′	880	2.4	18.5	In production
2. Long-range anti-aircraft and anti-missile missiles	SAM-A-25 Nike Hercules	Western Electric/ Douglas	USA	4 SP boosters + SP rocket	Radio command + homing	Ch. W or At. W	27′ 41.5′	~10,000	~3.5	75+	Operational
	SAM-N-6 Talos	Bendix-RCA	USA	SP booster + ramjet	Beam + semi-active homing	Ch. W or At. W	20.2′ 31.3′	~6,000	3+	~60	Operational testing, in production
	IM-99 Bomarc	Boeing	USA	Integral LP booster + 2 ramjets	Radar control radio command + active radar homing	Ch. W or At. W	46.7′	15,000+	2.5+	~250	Operational testing
3. Long-range anti-ballistic missile missiles	Nike Zeus	Western Electric/ Douglas	USA	SP booster + SP rocket	–	At. W	–	–	20+	300+	Under development
	Plato	Western Electric/ Douglas	USA	SP booster + SP rocket	–	At. W	–	–	20+	250+	Under development

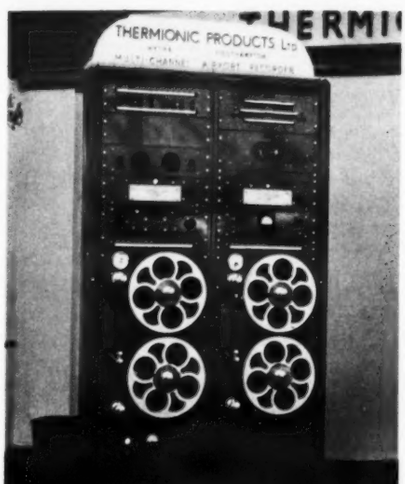
Telecommunications and Electronics

The first two pages of this month's report contain the conclusion to last month's "Telecommunications and Electronics at Farnborough".

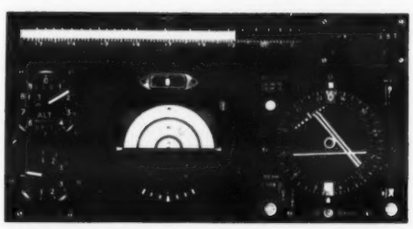


● A modified *Canberra* has been serving as test bed for the AIRPASS (Airborne Interception Radar and Pilot's Attack Sight System) developed by **Ferranti Ltd.** for the English Electric P.1B. The AIRPASS equipment comprises an advanced radar unit and a sighting system, and is sufficiently compact for installation in light fighter aircraft. The radar unit is housed in a single bullet-shaped container which, in the case of the P.1B, forms a complete centre-body in the engine air intake. It supplies the pilot with rapidly useable values which enable him to detect the target and lock the radar beam on to it. The target is then automatically tracked. Data are fed into the sight system, with the aid of which the pilot steers the aircraft into the attack position.

● **Thermionic Products Ltd.** exhibited their Mark XII version 14-channel recording equipment; this is a 2-bay installation comprising a master record bay incorporating playback facilities (left of picture) and a subsidiary recording bay (right). The equipment is designed for an unattended 16-hour period of recording; when the playback facility is employed the subsidiary record bay automatically takes over to provide continuity of reading. Provision is made for automatic restart in the event of a mains power failure. For playback any two channels can be selected for reproduction. Thermionic Products Ltd. has received orders for 50 equipments for delivery to the Italian Air Force.

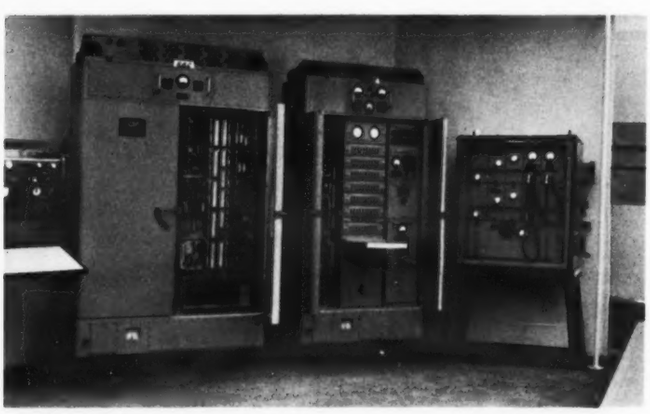


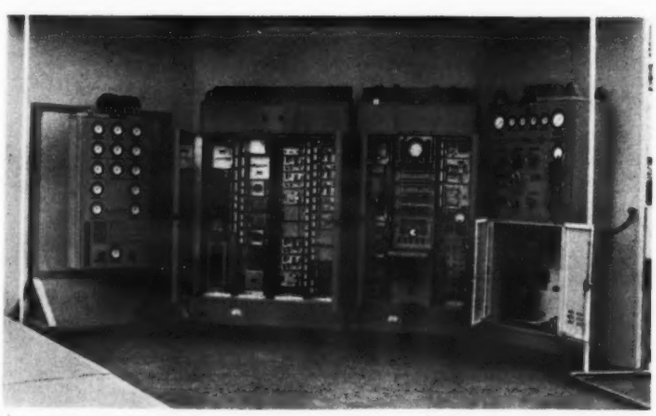
● **General Electric Company Limited** is now producing a radar equipment for the de Havilland *Sea Vixen,* and pictured herewith are some of the components which the company exhibited for the first time at Farnborough. Although details are still under security restrictions, the company has announced that this radar equipment "almost certainly has a higher performance than any other type now in service in the world".

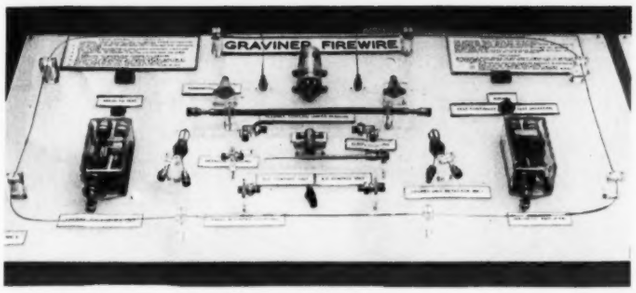


● **Kelvin & Hughes Limited:** The modified version of the Kelvin & Hughes integrated instrument system—Flight Data System—presents altitude and rate of climb on circular scales, instead of linear as previously. Using electronic computing aids the equipment presents all aerodynamic and flight dynamic information in a comprehensive display together with navigational data on a single panel: at the top of the panel IAS (indicated air speed) and Mach number are displayed; on the left, altitude and rate of climb; centre, attitude; and right, navigational data. In the picture herewith the Navigation Display is switched to Mode 2 for ILS.

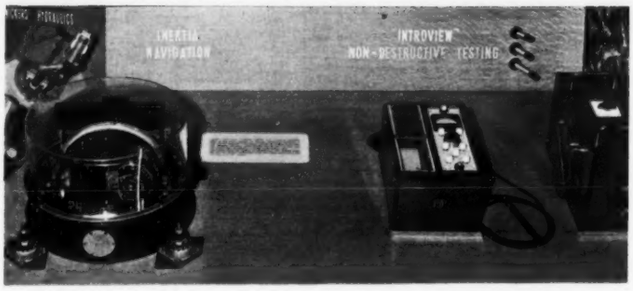
● Electronic equipment for the testing of the British *Seaslug* ship-to-air missile aboard ships. Left, the equipment for checking the control system **(General Electric Company Limited)**; right, the equipment for checking the semi-active guidance system **(Sperry Gyroscope Company Limited)**.



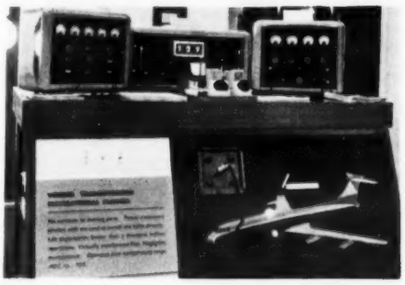




● **Graviner Manufacturing Company Limited** produces the well-known Firewire system for the detection of overheat and fire, the main components of which are shown in the picture. New control units for the system now work on 24 volt DC or 115 volt/400 cps. The actual Firewire consists of two concentric conductors, whose insulation resistance depends on temperature.

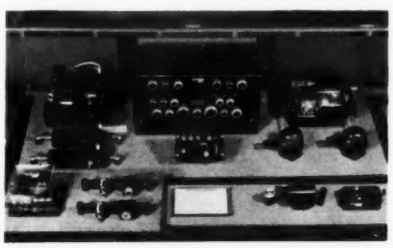


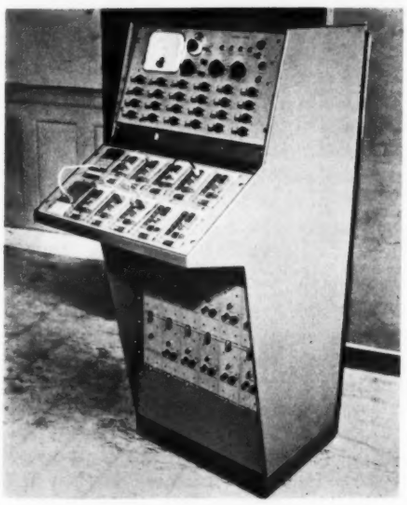
● **The Sperry Gyroscope Co. Ltd.** stand at Farnborough displayed the Inertia Navigation System stable platform (left of picture). It is the principal component of a new navigational system which was first flight tested four years ago. On the right is the new Sperry "Introview" flaw detector for the non-destructive testing of non-ferrous materials and components. This instrument employs the eddy-current principle and is particularly suitable for the testing of tubes. It is manufactured by Sperry under licence from Imperial Chemical Industries Ltd.



● **Venner Electronics Limited:** In addition to the TSA3 Frequency and Time Measuring Equipment and the TSA25 Batching Counter, the Venner Electronics Ltd. stand at Farnborough also displayed a Transistorized Navigational Flasher (pictured above), designed for the alternate switching of two low-voltage lamp circuits. This equipment employs power transistors to switch the bulbs directly, and contains no contacts or moving parts. The circuit utilizes a total of six power transistors: two type 2N352 in a specially designed multivibrator circuit (patents applied for), and two type 2N353 in each of the two switching channels. Supply voltage 21—28.5 volts DC; power rating 80 watts at 28 volts per channel; dimensions $6\frac{1}{8}$ in. square × $2\frac{1}{2}$ in. deep. Terminations: 6-pin Plessey MK IV socket. Specified performance is maintained over a temperature range of −40°C to +70°C.

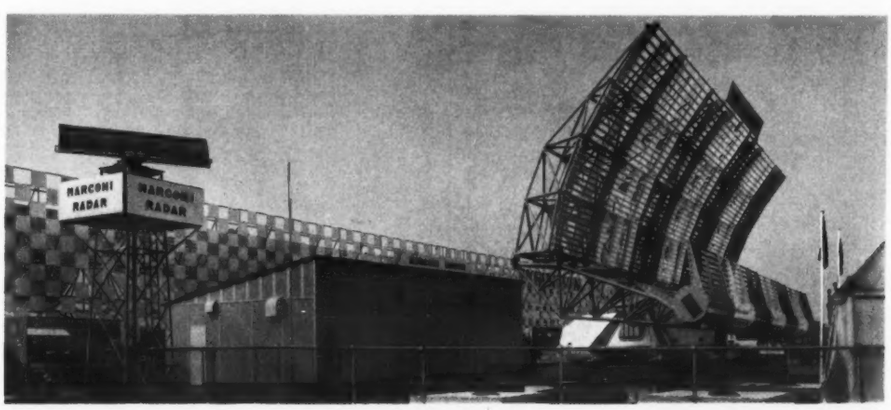
● **Louis Newmark Ltd.** exhibited at Farnborough the components of autopilot equipment which has been designed to provide three-axis automatic control and stabilization of a helicopter by means of servo operation of the cyclic controls and tail rotor. The three main modes of operation are: *Stabilization.*—The equipment gives the helicopter "hands off" stability but does not make it hold any datum attitude or heading. *Cruising* —attitude information is derived from the flight instruments, and these signals act as long-term monitors to maintain any desired attitude and heading. *Hovering*—a heading monitor is provided for the yaw channel so that the aircraft heading will be maintained irrespective of any changes of height or power, or changes in attitude or position in relation to the ground.





● **The Solartron Electronic Group Ltd.** showed for the first time the TY864 Minispace Computer, a desk-side or laboratory tool whose small dimensions qualify it for the description "Electronic Slide Rule". It is completely self-contained and comprises ten drift-corrected DC amplifiers. Cabinet dimensions: height 51 ins; width 20 ins; depth 30 ins.

● Eye-catchers above the exhibition grounds were the antenna groups for the new CR.787 airport surveillance radar (complete with secondary radar antenna) of **Cossor Radar & Electronics Limited** (left), the SNW51 storm warning radar (on left of right-hand picture) and the S264 50-cm airport surveillance radar (right), both by **Marconi's Wireless Telegraph Company Limited.**

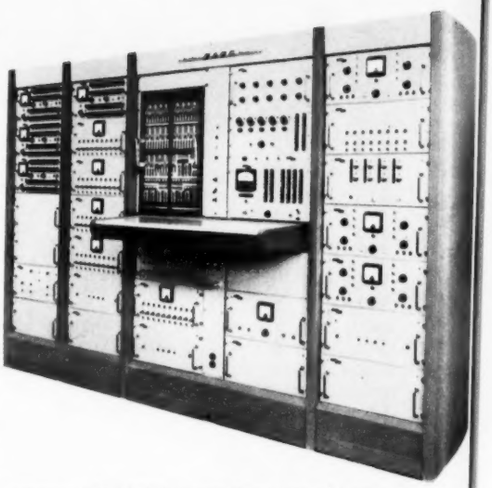


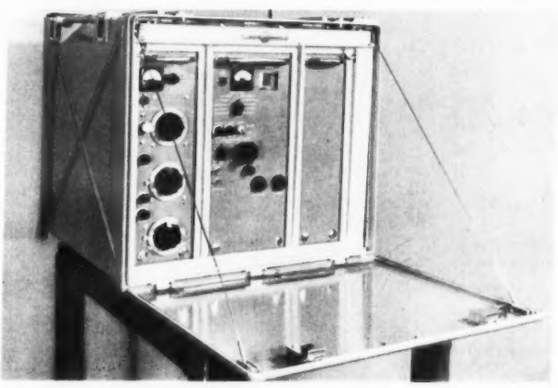
● **Lear Incorporated:** Illustrated herewith is the Type 4087 combined VOR/ILS display unit, one of the components of the NAVCOM equipment developed by the LearCal Division of Lear Inc. for transport and executive aircraft. The VOR/ILS display unit, which has good readability and light weight (1.5 lb.) may also be employed independently. Key to picture:

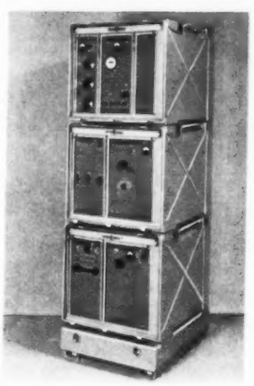
1. Glide slope deviation indicator.
2. ILS glide slope flag alarm (for too weak signals).
3. VOR and ILS Localizer flag alarm (for too weak signals).
4. Omni-bearing index.
5. Course deviation indicator.
6. TO/FROM VOR indicator.
7. Rotatable azimuth card.
8. Blue/yellow "off course" indicator.
9. Reciprocal course.
10. Omni-bearing selector knob.

● **Electronic Associates Inc.,** who also maintains a European Computation Centre and Regional Office in Brussels, is producing the Model 3033 B Dataplotter illustrated herewith. This is a complete digital-to-analogue data reduction system; based on the binary coded decimal system, it converts inputs from paper tape, IBM cards and from the keyboard into analogue data for plotting. Data output is either in the form of a point plot (12 different symbols) using either punched cards or tape, up to 50 points per minute; continuous line plot, up to 25 points per minute. Data are recorded on paper measuring up to 30 × 30 in. which is available either in sheets or rolls. Data accuracy: point plot 0.05% of full scale; continuous line plot 0.1% of full scale.

● The Berkeley Division of **Beckman Instruments Inc.** started work some six years ago on the development of the EASE Analogue Computers. Today Beckman computers are operating in many large companies, as for example, Boeing, Chrysler and Allison. The new EASE 1100, pictured herewith, is designed on the unit assembly principle; this offers the advantage of relatively low initial cost in establishing a basic equipment, which can then be extended, step-by-step, up to the full capacity of the EASE 1100. The multiple possible combinations of the individual units permit a very wide range of problems to be handled. The precision elements of the equipment, resistances and capacitators are thermostatically housed, and the accuracy of the critical components thus becomes better than 0.005%. The patchboard is built up from single units with overall shielding. As many inputs as required may be connected with any one of the amplifiers. Push button control is provided for all amplifiers, potentiometers, multipliers, function generators, and for the readout. Automatic problem control of the computer permits a rapid check of all components. Servo control of the function generators and potentiometers can be set up with an accuracy of 0.01% in a maximum time of 3 seconds. The "Do/It-System" allows automatic output and input in digital form.







● **Compagnie Française Thomson Houston** has been awarded a multi-million franc contract by the French Air Ministry for the production of ground-to-air telecommunications equipment. The contract is for VHF/UHF ground stations (225—400 Mc/s) built up from unit components permitting various combinations of equipment. The individual units are in standard housings 25.6 in. long × 21.3 in. wide × 19.7 in. high.

Depending on the combination employed, the following transmitting equipments are available: TH.C.9600 crystal controlled: TH.C.9601 with manually controlled oscillator; TH.C.9605 with remote control. All three equipments comprise two main units. The first housing (top of right-hand picture) contains, or can contain: an oscillator (manual or remote control), a common auxiliary rack and a command receiver. The second housing (centre) contains: a 20 watt transmitter and a supply/modulator unit. For higher output (100 watt) a third housing (below) containing a TH.C.9602 amplifier with supply unit may be added. All the housing units are stacked on a TH.C.9640 base which also contains all connections. The receiving equipment is mounted in a single housing and here also various models are available: TH.C.9610 crystal controlled; TH.C.9611 manually controlled oscillator; TH.C.9615 remotely controlled. The receiver (left-hand picture) comprises a manual or remote controlled oscillator; a VHF/UHF receiver; and a command receiver.

● The Semiconductor Division of **Hoffman Electronics Corporation** has announced a new line of silicon zener voltage regulators. It includes 38 separate types in each of three power categories: ¼ watt (left), 1 watt (middle) and 10 watts (right).

● **Standard Elektrik Lorenz A.G.** has developed a VHF/UHF D/F equipment employing the Doppler effect. A major advantage of this system is that the equipment can be built up with a multi-wavelength base-line, without the display ambiguity which occurs, for example, with the Adcock aerial system. By this method the errors arising from multi-path reception as a result of reflection can be considerably reduced. The large-base Doppler D/F equipment is thus largely free from ground effects.

Thirty antennas are employed in a circular layout with a diameter of several wavelengths. The antennas are connected to the receiver input in a certain sequence and this corresponds to a virtually physical movement of an antenna in an electro-magnetic propagation field. In this system, the incoming frequency is modulated in rhythm with the antenna scanning. The minimum frequency variation then occurs when the virtually physical movement is at 90° to the direction of incidence.

The antennas and display system are constructed on a mechanical basis and contain no valves, transistors or other electronic components. This offers a high degree of stability and operational safety with the most simple and clearly arranged construction.

The Lorenz Doppler D/F equipment consists of an unmanned D/F station and remote installations for the display of the D/F data. One or more remote installations may be employed to display the data at different points where, completely independently of each other, QTE, QDM or QTR may be read off. By employment of a parallax-free coordinate display the bearing is presented as a light blip on an approximately 6-inch diameter transparent scale.

● **Collins Radio Company** announces that the company has recently carried out radio transmission tests, in conjunction with the Signal Communications Department of the U.S. Army Electronic Proving Ground, using the moon as a passive relay station. Teleprinter transmissions from the Fort Huachuca, Arizona, area were received via the moon in Encino, New Mexico. A frequency of 810 Mc/s was selected in order to increase the effectiveness of the antenna systems and to take advantage of lower signal losses in the transmission path.

First radio contact with the moon was made in 1946 by the U.S. Army Signal Corps at Belmar, New Jersey; a modified World War II radar set was used to transmit a 100 Mc/s signal. In 1950 an Australian group obtained moon echoes on 20 Mc/s using equipment and techniques normally employed on the London-Australia shortwave broadcast service. In 1952 Collins and the National Bureau of Standards used the moon as a reflector to relay radio-teletype signals from Cedar Rapids to Sterling, Virginia; this test employed a frequency of 148 Mc/s.

The distance involved in this type of communication means that a signal requires about 2.5 seconds to travel a path transmitter-moon-receiver. If an artificial satellite can be used for this method of communication, the transmission time and the losses can be drastically reduced.

● **Rohde & Schwarz** is now producing a two-channel frequency response display unit known as the Polyskop (Type SWOB BN 4244), for measurements on dipoles and quadripoles. Frequency range 0.5 to 400 Mc/s; attenuation 45 db; frequency variation ± 0.2 to ± 50 Mc/s.

● **Standard Telephones & Cables Ltd.** have pointed out that the description of the STRAD equipment published in *Interavia* No. 10, 1958, page 1090, contains a misleading reference to a "torn-tape system". The company suggests that the STRAD equipment (Signal Transmitting, Receiving and Distributing Equipment) should more accurately be described as "a fully automatic and fully electronic system capable of receiving information in telegraph code and automatically (or by push-button control if desired) retransmitting on one or more telegraph channels as directed by the routing code in use. STRAD utilises magnetic storage in either drum or ferrite forms."

Link Simulator for the Douglas DC-8

Above. The simulated flight path is traced on maps in the control room. The instructor makes the appropriate control tower and checkpoint communications, and introduces radio and navigational signals and the effects of winds of varying direction and velocity.

Left. Inside the mock-up of the DC-8 cabin. The pilot sees the simulated airport area through the cabin window.

At the beginning of September, United Air Lines brought into operation at their Denver, Colorado, flight training centre a new DC-8 simulator, developed and produced by Link Aviation Inc., a subsidiary of General Precision Equipment. This simulator, the Link Mark IV Visual System, is also on order by Eastern Air Lines, Scandinavian Airlines System, KLM—Royal Dutch Airlines, Alitalia, Japan Air Lines and Trans-Canada Airlines. The equipment not only simulates all instruments, movements and noises of the DC-8 but also presents a visual picture of the airport for simulated take-off, approach flight and landing.

The main section of the trainer is a full-size mockup of the DC-8 pilot's cabin, equipped with the same controls, instruments and radio aids as employed in the aircraft. Dials, gauges and instruments are linked to a series of analogue computers, and indicate the engine and flight conditions of the simulated flight. Weather and radio signals can be fed in by the instructor.

Pilot vision is provided through a closed circuit television system, and on simulated take-off and landing a replica of an airport is projected onto a 12 ft. × 15 ft. screen in front of the cockpit. A miniature relief map built to a 300 : 1 scale is scanned by the camera whose movements are governed by the electronic response of the simulated aircraft to the pilot's controls, and an enlarged image is projected. The projector is mounted above the cabin. The camera is also equipped with dual lights which simulate the aircraft landing lights in night operations.

Finally, the manufacturers point out that the Mark IV Visual System has potential employment for adaptation to simulate operations such as air refuelling, carrier landings and emergency landing and ditching procedures at sea.

Behind the scenes: left, the television room with the relief maps; right, analogue computers and servo mechanisms.

First in-flight refuelling of a Convair B-58 Hustler *supersonic bomber by a Boeing KC-135 jet tanker somewhere over Texas. The* Hustler *pilot, Convair Manager of Flight and Chief Test Pilot (Fort Worth) B.A. Erickson first made two practice passes, before hooking up with the KC-135's flying boom. All went off according to programme, and Erickson later stated that he had no trouble in holding the delta-wing bomber, which is designed for speeds of 1,300 m.p.h. or more, down to the subsonic speed required for the refuelling manoeuvre.*

A new McDonnell cargo helicopter, capable of carrying 2,000 lb. of payload over a distance of 80 nautical miles, has been demonstrated for the first time in flight. It is here seen lifting a sister helicopter of the same type. Designated the Model 120, it is equipped with three AiResearch GTC-85-35 gas turbine compressors, which feed compressed air to pressure jet burners at the blade tips.

Progress in Pictures

The North American UTX Sabreliner *jet-powered training and communications aircraft began flight testing a few weeks ago. Fitted with two General Electric J85 lightweight jet engines, the* Sabreliner *can carry up to ten persons including the crew and fly at 500 m.p.h. at cruising altitudes of around 39,000 ft. Its span is 42 ft., and gross weight 15,320 lb.*

The B-52G, specially designed as a platform for the new GAM-77 Hound Dog *supersonic air-to-surface missile, has gone into production for the USAF Strategic Air Command at Boeing's Wichita Division. Its increased range will enable the 450,000-lb. bomber to cross oceans and return to bases in the United States without refuelling. It also has more powerful engines and a modified fuel storage system, with the whole wing subdivided into integral tanks. On a typical long-range mission the B-52G is said to carry two air-to-surface missiles under its wings.*

The Chance Vought F8U-3 Crusader III *carrier-based naval supersonic fighter can carry three* Sparrow III *air-to-air missiles, mounted in semi-buried position underneath the fuselage. To accommodate the foremost missile beneath the fuselage, the nose-wheel unit had to be displaced sideways.*

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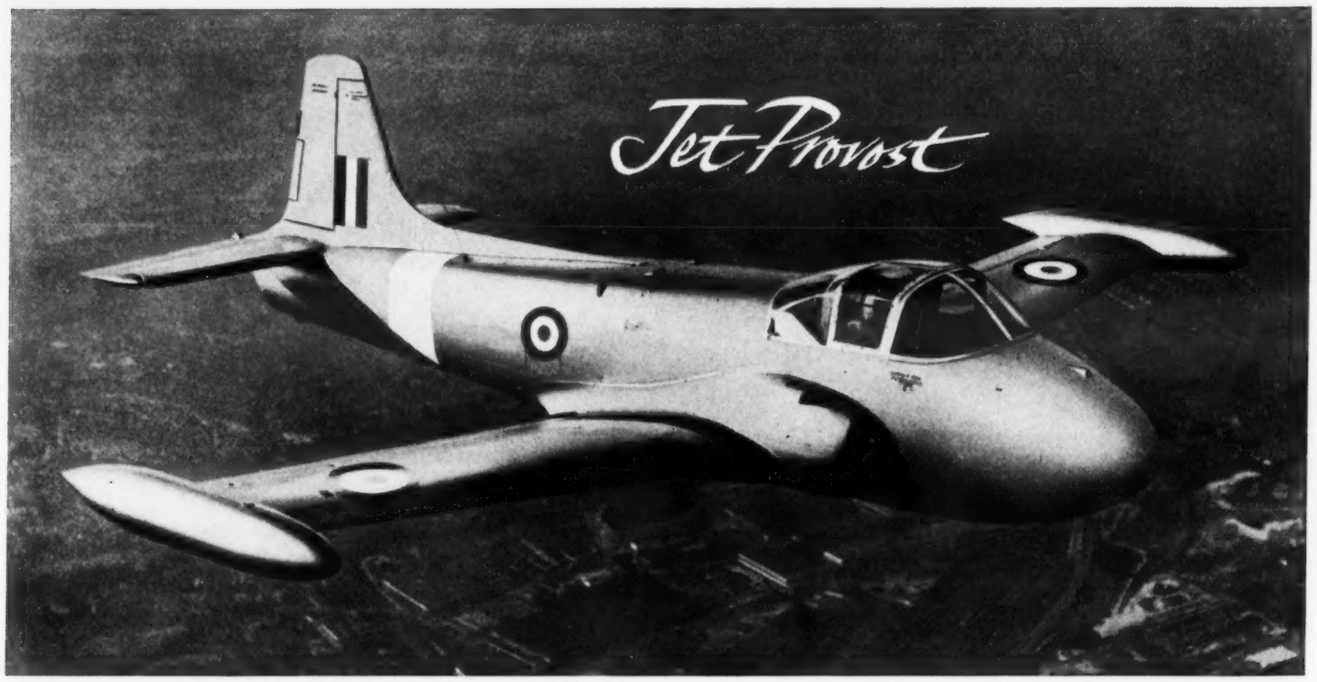

Two years service with the Royal Air Force has established the Jet Provost ab initio/basic trainer as the best aircraft for its purpose, and the Mk3 powered by one Armstrong Siddeley Viper Turbo-Jet is now in production for the re-equipment of Flying Training Command.

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Grouping of Interests in European Air Transport

Early in October 1958 British Overseas Airways Corporation opened scheduled DH *Comet* 4 services across the North Atlantic, and on October 26th a Pan American World Airways Boeing 707 carried 111 passengers on the company's first regular service between New York and Paris. In January 1959 American Airlines plans to introduce Boeing 707s on its transcontinental New York-Los Angeles services. In short, it is high time to talk about the *forthcoming* jet age in the *present* tense. The airlines' " breathing space ", in Europe as elsewhere, is rapidly nearing its end.

It is no secret that organizational and economic preparations for jet traffic have lagged behind the impressive development of new aircraft. For example, a widely-studied ICAO memorandum published this summer was outspoken in its criticism of the ground services' technical status, and its assessment of the economic situation led to the anxious question of what measures the smaller operators in particular plan to take in order to cope with the expected surplus capacity and the increased financial burden arising from the introduction of new fleets.

Among other proposals, ICAO recommended increased cooperation between airlines through fleet interchange agreements, joint purchasing of spares and accessories, joint crew training and maintenance.

Actually there is nothing particularly new about this. The Strasbourg European Civil Aviation Conference (of 19 countries) had made similar proposals when its efforts at drafting a multilateral agreement had broken down. Much earlier, in 1949, the late Albert Plesman of KLM—a great European, though under the Plesman flag—had proposed the Beneswiss agreement and tried to set up an organization uniting Holland's KLM, Belgium's Sabena and Switzerland's Swissair. [1] However, no practical steps were taken until Max Hymans of Air France established contact with Lufthansa (before the German Treaties were signed) and Alitalia, and prepared a pool agreement of far-reaching scope for the North and South Atlantic.

So much for the back history.

Two neutrals in harness

And now two European companies have announced a much closer association of interests than has ever been included in earlier pool arrangements: on October 6th Swissair and Scandinavian Airlines System signed an agreement in Zurich under which the two airlines will charter each other some of their jet aircraft for an initial period of four years. In each case the lessee will be entitled to operate the aircraft under its own flag. The Swissair Board has ordered five Convair 880s for delivery in late 1960 and will lease two of them to SAS. In return, SAS will lease to Swissair four of the sixteen Sud-Aviation *Caravelles* it has on order.

At the same time, the two companies agreed on joint maintenance of their combined jet fleets: Swissair will overhaul the Convair 880s, while SAS will be in charge of maintenance for the Douglas DC-8s and *Caravelles*.

Going even further Swissair and SAS decided " *to further strengthen their collaboration, both commercially and operationally* ",

Ernst Schmidheiny, Chairman of the Swissair Board.

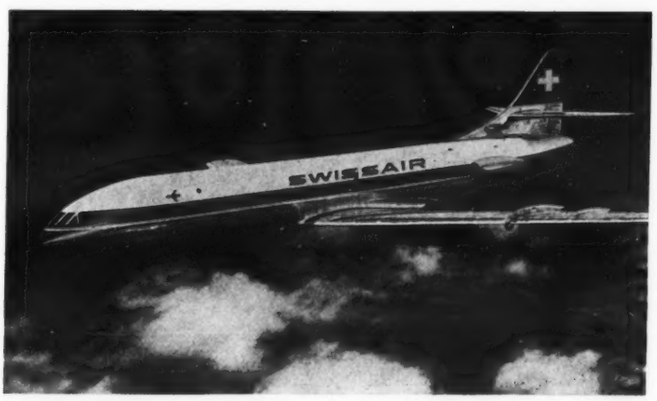
Marcus Wallenberg, Board Chairman of Scandinavian Airlines System.

Dr. Walter Berchtold, Swissair President.

Åke Rusck, SAS President.

[1] Further information on earlier technical and economic cooperation between individual European airlines is given in a 1952 ICAO circular prepared by the French *Institut de Transport Aérien* : " Existing Forms of Commercial and Technical Cooperation between European Airlines ".

Under the SAS-Swissair agreement on joint utilization of fleets the Scandinavian company will lease Swissair four of the sixteen Sud-Aviation *Caravelles* it has on order and undertake all *Caravelle* maintenance.



Swissair has ordered five Convair 880s, will charter two of them to SAS and be responsible for maintenance of all five.

in order to achieve a decisive lowering of operating costs and avoid duplication.

From the *fleet* point of view the effects of the Swiss-Scandinavian agreement are obvious: thanks to joint equipment planning—which began when the DC-8s were ordered, and both companies agreed to take exactly the same model—Swissair and SAS will have a rationalized " *three-type fleet* ": DC-8s (mean range 5,000 miles) for non-stop service across the North Atlantic; Convair 880s (mean range 3,500 miles) for long-distance routes of medium stage lengths to South America, the Middle and Far East; *Caravelles* (mean range 1,550 miles) for European services.

From the *legal* point of view, the leasing or chartering of aircraft between airlines is not an innovation. In the United States such interchange agreements are an everyday affair. For example, PAA and National Airlines recently agreed to exchange Douglas DC-8s, and there are some twenty other interchange agreements in force in the country. But arrangements of this kind are very rare in Europe, not only because of the absence of standardization among fleets but above all because of legal difficulties arising from differences in national regulations concerning aircraft registration and personnel licensing.

It is also obvious that the Swiss and Scandinavian partners will benefit *commercially*. Apart from the several millions of dollars which will be saved on the purchase of spares and on operating costs, the agreement will bring many advantages to both companies. Swissair will doubtless welcome the opportunity of tying in with SAS's Polar services to the United States and Japan, and SAS has an economically strong partner in the Swiss " watchmakers " with their hard currency, which greatly simplifies aircraft purchases in the United States. Another advantage to SAS is Switzerland's central position, which counterbalances Scandinavia's peripheral situation on the European continent. Commenting on the arrangement, the distinguished Stockholm newspaper " Morgon Tidningen " (which has since ceased publication for internal reasons) wrote: " Switzerland with its strategic transport position in the heart of Europe can offer SAS a full countervalue for the latter's bigger technical resources. It may even be that, as a result of the new agreement, SAS will lose interest in cooperating with Austria, particularly as the Austrians themselves do not seem to be at all clear on the future orientation of their air transport industry ". (The Austrian Airlines General Meeting called for the first week in November may perhaps bring greater clarity.)

This concerns the whole of Europe

What the Scandinavian and Swiss negotiators mean when they talk about " further strengthening their collaboration both commercially and operationally ", only the future will show. In recent years SAS has proved to be something of an expert in overcoming difficulties arising from national sovereignties in air transport, and it is hardly likely that " close cooperation " will remain an empty phrase.

At any rate the SAS and Swissair tie-up entails a community of interests with which European and world air transport will have to reckon. Neither of the two partners is in any way a *quantité négligeable* even in its present status, and their combined revenue passenger-kilometres, for instance, bring them into fourth place in the list of IATA airlines:

Passenger volume 1957
(IATA figures, July 1958)

	Passenger-kilometres (in thousands)	Passengers
TWA	7,010,663	4,802,766
PAA	5,777,199	2,784,521
Air France	2,995,672	2,385,640
BOAC	2,124,975	459,829 [1]
KLM	1,967,003	881,960
SAS	**1,646,635**	1,450,344
BEA	1,469,680	2,727,356
Sabena	928,619	615,716
Swissair	**874,027**	985,216
Lufthansa	488,027	380,862
Iberia	477,967	734,996
Alitalia [2]	360,868	221,271

[1] Unlike certain other companies, BOAC counts each passenger on its world-wide network only once, regardless of any stop-overs he may make en route.

[2] Excluding LAI figures for the period up to its absorption by Alitalia on October 6th, 1957.

*

At the present time there are two " communities of interests " in Europe which officially involve five of the major continental European airlines. It is also by no means impossible that Sabena may join the France-Germany-Italy group.

When the new Lufthansa was formed, Air France resolutely turned its back on old resentments and opened its arms and Orly Airport to its German sister. Rights to operate via Paris across the North and South Atlantic, previously steadfastly refused to other European airlines, were readily granted to the Germans, who thus acquired their first access to the West's passenger reservoir. Air France's diplomats in no way acted out of sentimental reasons but were motivated by the hope that in this way they could bring their influence to bear in the formulation of Germany's new air transport policies. In the French flag carrier's eyes there was altogether too much flying in the " masterless German skies ", particularly by certain European airlines with an inadequate hinterland.

Germany's air transport negotiations with other European countries, however, proceeded a good deal less smoothly, and an agreement with Scandinavia signed in November 1955 was initially refused ratification. When finally, in September 1956, a modified draft of the agreement was accepted, the landing rights accorded to Scandinavia were on the distinctly modest side. The SAS representative in Germany, Consul Kim Urbye, commented dryly that the agreement was " a compromise in the direction of mutual understanding; but as everybody knows a compromise never meets everybody's wishes ".

Holland's KLM also had to wait patiently for quite some time before it could do business with the Federal Republic. And today ?

The Netherlands flag carrier is a company of stature and can allow itself a certain freedom of action. But is it really willing to go it alone ? Theoretically it can today join the Swiss-Scandinavian group or perhaps the France-Italy-Germany (plus Belgium ?) group; and there may perhaps be a third possibility...

However, it still has time to think things over, and this is probably what the company's diplomat Dr. L. M. Slotemaker is doing right now. Holland maintains broad commercial relations with its eastern neighbour, the Federal German Republic, and these relations could today perhaps be more easily utilized in the air transport field, since the change of staff at the Bonn Transport Ministry may enable KLM to get a more favourable hearing. Whether and how far such a speculation—and it is no more than a speculation—proves correct may be revealed in the near future.

One thing is certain: despite the difficulties encountered, the European airlines are beginning to get together on a closer cooperative basis. While Government representatives at Strasbourg have been talking for years without reaching any very concrete results, the practical men who run the airlines have shown that only action can lead to success.

Convair 880/600

New Medium-Range Airliners with Long-Range Capabilities

The order for five Convair 880-25s announced by Swissair at the beginning of October (for joint use by Swissair and SAS) raises the total order book for jet transports held by the Convair Division of General Dynamics Corporation to 93 aircraft, plus options on another 31*. The first of these transports, for 86 to 110 (or even 122) passengers, will go into service with TWA in spring 1960, with Swissair in autumn 1960 and with American Airlines in summer 1961; the first prototype is due to make its maiden flight in December 1958 or early January 1959.

These aircraft fall into three different basic types, to ignore the usual interior modifications, such as differing seating arrangements and variants in auxiliary accommodations:

- *CV 880-1/2/3 (Model 22):* basic light weight version, with General Electric CJ805-3 jets; no slats;
- *CV 880-25 (Model 31):* same engines, but designed for increased take-off weight and longer range, and equipped with slats;
- *CV 600 (Model 30):* transcontinental high-speed version with General Electric CJ805-21 aft-fan jets, larger wing area, bigger tailplane and longer fuselage; designed for higher take-off and landing weights, equipped with slats.

All three basic models are powered by four CJ805 jet engines, the civil version of the General Electric J79, plus in the case of the CV 600 bypass components fitted behind the (three-stage) turbine of each basic engine. Described by General Electric as an aft-fan, this component consists of a single-stage turbine wheel rotating freely in the exhaust stream, with a peripheral single stage fan for the secondary air. Thanks to the aft-fan, the normal sea level take-off thrust of the CJ805 (roughly 11,200 lb.) can be increased by no less than 35 percent; at the same time en route specific fuel consumption is cut by from 8 to 18 percent, depending on cruise conditions, and noise level during take-off and climb is reduced. However, the aft-fan component is not an unmixed blessing, since it requires thicker pods and a longer undercarriage. Moreover, because of its higher overall thrust, it is fully economic only when payload and take-off weight (hence wing area and fuselage length, etc.) are also increased.

* List of purchasers according to latest available information: TWA 30 CV 880-1s, Delta Airlines 10 CV 880-2s, American Airlines 25 CV 600s (plus option on another 25), Capital Airlines 15 CV 880s (unspecified), Transcontinental S.A. 4 CV 880s, Real 4 CV 880s, Swissair and SAS 5 CV 880-25s (plus options on another 6).

Artist's impression of the CV 880-25 (Model 31) long-range over-water version as ordered for Swissair and SAS. Powerplant, four General Electric CJ 805-3s.

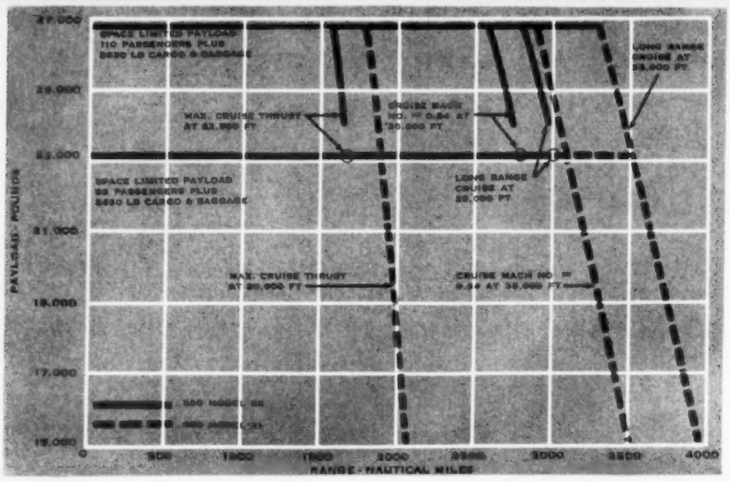
Nevertheless Convair is convinced that the "mating" of the CJ805 with the now completed airframe designs will lead to an "ideal marriage" and replies to the suggestions occasionally put forward by airline operators that certain alternative engines be offered, by showing that both cruising speed and range would suffer not inconsiderably. In fact, with its single-spool design—only three main bearings—the CJ805 has a very low weight (2,800 lb. without aft-fan, or roughly 25 percent of take-off thrust) and low fuel consumption at all altitudes.

Other design principles listed by the manufacturers:

- *Very high cruising speeds (equivalent to Mach 0.84 to 0.90) at medium altitudes (20,000 to 23,000 ft.) to ensure shortest possible block times.* The faster CV 600 is fitted with four antishock bodies (23 ft. and 25 ft. long) on the wing trailing edges, which are expected to raise the aircraft's critical Mach number to roughly Mach 0.91, thanks to closer observance of the area rule. Once they are in service, the CV 880 and more especially the CV 600 promise to beat all the journey time records set up by jet transports.
- *Adaptable range:* Stages of from approximately 1,000 to 3,200 nautical miles can be flown with roughly the same degree of economy, as

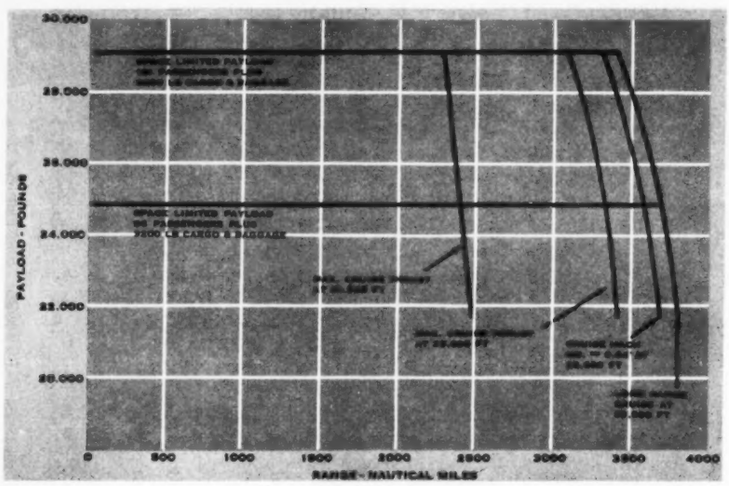
Trans-World Airlines will put thirty CV 880-1s into service starting in spring 1960. Picture shows a group of TWA officials studying passenger handling with the aid of a "satellite" air terminal model.

Inside the cabin mockup of TWA's 88-seat first-class version: two seats on either side of a wide central aisle (24 to 28 in.); one window per passenger; varying form and colour treatment to avoid the "tunnel effect" of long passenger cabins.



Payload/range diagram for the CV880-3 (Model 22) and CV880-25 (Model 31). Based on the full space-limited payload of 110 tourist-class passengers (upper horizontal line) or 88 first-class passengers (lower horizontal line), in both cases plus baggage and freight, the diagram shows the ranges (in nautical miles) obtainable with given cruise data, if necessary with reduced payload (in pounds). The curves apply to zero wind and 9,600 lb. reserve fuel, sufficient for 45 minutes stacking plus 200 nautical miles diversion at 30,000 ft.

Payload/range diagram for the CV600: Same basic conditions as above, but with the following modifications: space-limited payload for 121 tourist-class passengers or 96 first-class passengers; reserve fuel 11,200 lb.



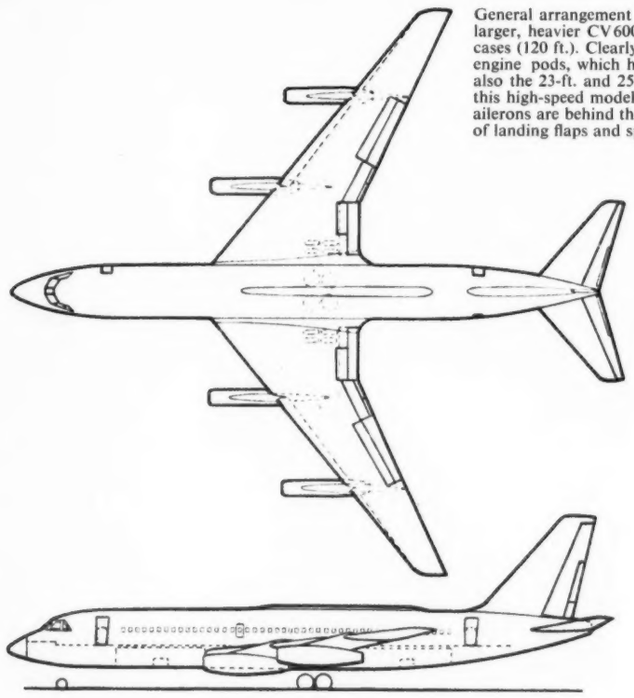
Type	Convair 880-3	Convair 880-25	Convair 600
Engine	G.E. CJ805-3 Thrust reverser Silencer	G.E. CJ805-3 Thrust reverser Silencer	G.E. CJ805-21 Thrust reverser —
Manufacturers' designation	Model 22	Model 31	Model 30
Max. sea-level static thrust	4 × 11,200 lb.	4 × 11,200 lb.	4 × approx. 15,000 lb.
Span	120 ft.	120 ft.	120 ft.
Fuselage length	124 ft. 2 in.	124 ft. 2 in.	135 ft. 5 in.
Gross wing area	2,000 sq. ft.	2,000 sq. ft.	2,250 sq. ft.
Sweep back	35° at 30% chord	35° at 30% chord	35° at 28% chord
Aspect ratio	7	7	6.2
Take-off and landing aids	Double slotted flaps —	Double slotted flaps Slats	Double slotted flaps Slats
Tailplane area	395 sq. ft.	395 sq. ft.	449 sq. ft.
Rudder unit area	295 sq. ft.	295 sq. ft.	295 sq. ft.
Height of tail tip above ground	36 ft.	36 ft.	39 ft. 6 in.
Max. ramp weight	185,000 lb.	204,000 lb.	239,000 lb.
Max. take-off weight	184,500 lb.	203,400 lb.	238,200 lb.
Max. landing weight	132,800 lb.	155,000 lb.	180,000 lb.
Zero fuel weight	117,000 lb.	126,000 lb.	149,000 lb.
Operational weight empty	90,000 lb.	96,000 lb. [1]	118,000 lb.
Max. fuel capacity	10,770 U.S. gals	13,870 U.S. gals	15,100 U.S. gals
Manufacturers' max. space-limited payload	e.g. 23,200 lb. (88 passengers + freight)	e.g. 23,800 lb. (86 passengers + freight)	e.g. 29,200 lb. (121 passengers + freight)
Passenger capacity (first class)	88 (four abreast)	86 (four abreast)	98 (four abreast)
(tourist class)	110 (five abreast)	110 (five abreast)	122 (five abreast)
(mixed version)	94 (four and five)	86 (plus lounge) (four and five)	101 (plus lounge) (four and five)
Freight and luggage capacity	863 cu. ft.	863 cu. ft.	928 cu. ft.
Max. true cruising speed at moderate altitude	522 kn (at 22,500 ft.)	525 kn (at 20,000 ft.)	550 kn (at 21,500 ft.)
Max. true cruising speed at high altitude	484 kn (at 35,000 ft.)	486 kn (at 35,000 ft.)	513 kn (at 35,000 ft.)
Most economic long-range cruising speed at high altitude	452 kn (at 35,000 ft.)	452 kn (at 35,000 ft.)	470 kn (at 35,000 ft.)
Still-air range with reserve, depending on payload and cruising speed	1,600–3,000 nm (see diagram)	1,800–4,000 nm [2] (see diagram)	2,300–3,800 nm (see diagram)
CAA runway length at full take-off weight at sea-level, ISA, according to regulation SR.422	7,550 ft.	~ 8,850 ft.	~ 8,900 ft.
CAA runway length at full take-off weight at sea-level, at +22°C, according to regulation SR.422	9,350 ft.	~11,000 ft.	~11,300 ft.

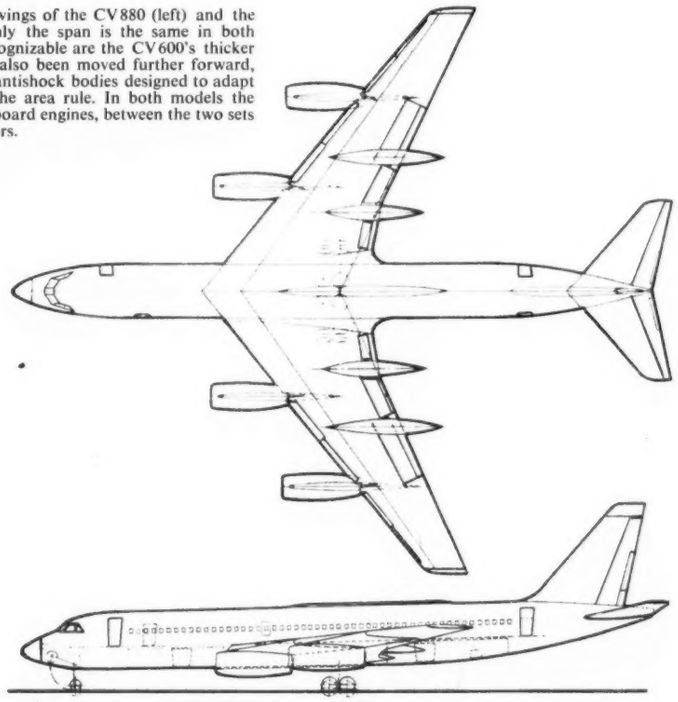
Notes:

[1]) Operational weight empty of the long-range over-water version (for Swissair) with two large fully-equipped galleys, four toilets, complete over-water provisions, radio and radar equipment.

[2]) The still-air range includes flights with full payload (23,800 lb.) at a cruising speed of Mach 0.80 at 35,000 ft. over distances up to 3,200 n.m.: here mark-ups of 7% on the specific fuel consumption at this altitude (for the silencers and contingencies) are allowed, and reserve fuel over airport of destination weighs at least 10,000 lb.

General arrangement drawings of the CV880 (left) and the larger, heavier CV600: only the span is the same in both cases (120 ft.). Clearly recognizable are the CV600's thicker engine pods, which have also been moved further forward, also the 23-ft. and 25-ft. antishock bodies designed to adapt this high-speed model to the area rule. In both models the ailerons are behind the inboard engines, between the two sets of landing flaps and spoilers.





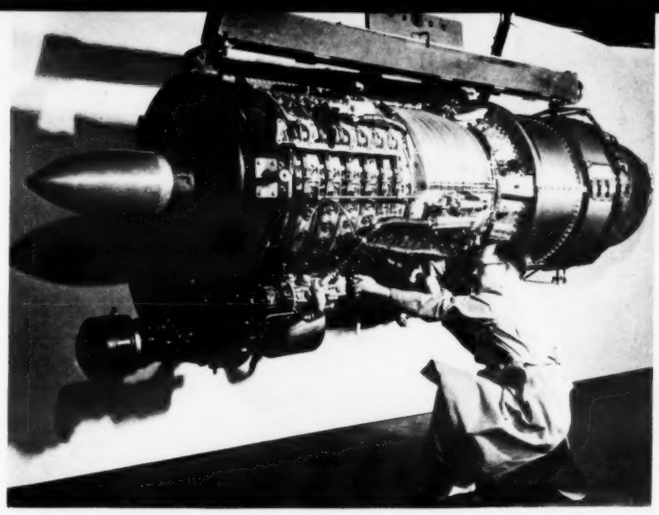
the curves for operating costs per seat-mile versus range begin to approach their minimum at about 1,000 nautical miles. For somewhat longer ranges, auxiliary fuel can be carried (e.g., 3,100 U.S. gals. in the inboard wing sections of the CV 880-25), though this of course reduces payload. Operators can break even with a load factor of 60 percent on very short stages, for example 250 nautical miles, at any rate under American operating conditions.

• *First class seats four per row, tourist class seats five per row:* Convair has drawn practical conclusions from the fact that the travelling public does not take willingly to three-abreast seating, particularly to three persons sitting on both sides of the centre aisle. In the luxury class layout therefore there will be only two seats on either side, while the high-density layout will have five seats per row, or alternating rows of four and five (the so-called club car layout). The CV 880-25s ordered by Swissair, for example, will be equipped with 30 first class seats (or 22 sleeper-type chairs) and 56 tourist seats (economy class). In addition there will be four toilets and two very roomy galleys. Indirect lighting and varied treatment of cabin roof and walls will overcome the disturbing "tunnel effect" even if no partitions are used. And thanks to the many small windows practically every passenger will have his individual observation post.

• *Moderate take-off and landing distances:* Thanks to their powerful engines, combined with *double slotted flaps,* the three basic models have moderate take-off and landing distances, which will enable them to operate from almost all existing airports (see table). *Thrust reversers* (which supply up to 50 percent of the take-off thrust as brake thrust) can further shorten the landing run. Both the CV 880-25 and the CV 600 carry *slats* which can either be operated automatically (in conjunction with the landing flaps) or be independently controlled. To calm the fears of airport managements all CJ805-3 engines are fitted with *silencers,* while the aft-fan component on the CJ805-21 renders additional mixing nozzles for exhaust gas and outside air unnecessary.

*

From the structural viewpoint Convair's airframe is described as a prime example of fail-safe design. An unusually thick Alclad skin—up to 0.25 in. thick on the wing, up to 0.1 in. on the fuselage—ensures low safe loads in flight, good resistance to fatigue, and long life; the

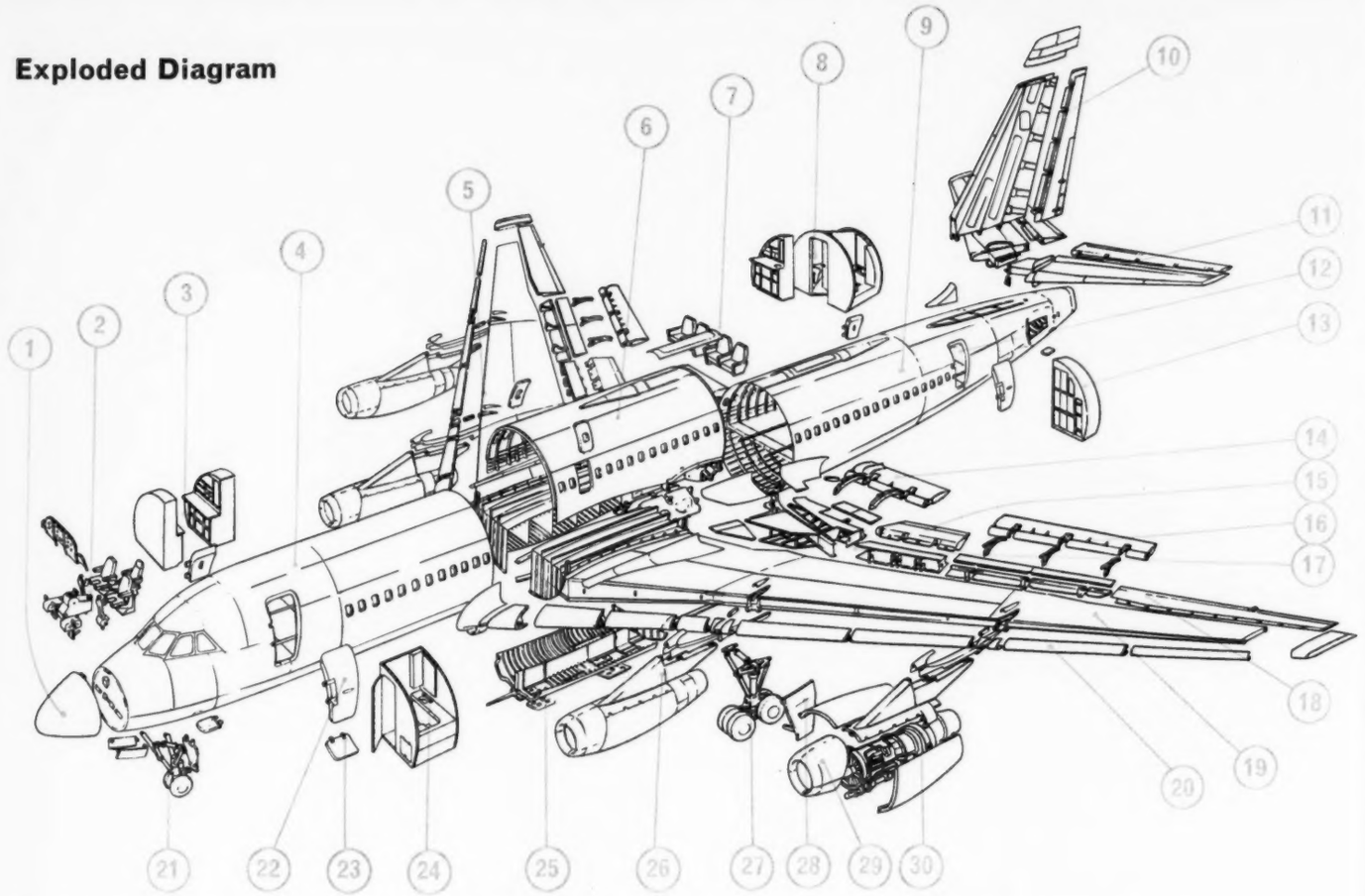


The General Electric CJ805-3 civil jet for the CV880: 17-stage axial compressor with variable stator blades in the first six stages; cannular combustion chamber; three-stage turbine. Take-off thrust 11,200 lb.; installed weight 2,800 lb.; compression ratio 12 : 1; frontal area 5.7 sq. ft. Below the compressor inlet are the pneumatic starter and the AC generator.

All CJ805-3 engines for the CV880 are equipped with a thrust reverser (louvers with internal deflector) and daisy-petal silencers. The CJ805-21 aft-fan engine for the CV600 requires no silencer, and the thrust reverser (which also controls the secondary air flow) consists of clamshell type half cylinders at the end of the exhaust pipe.

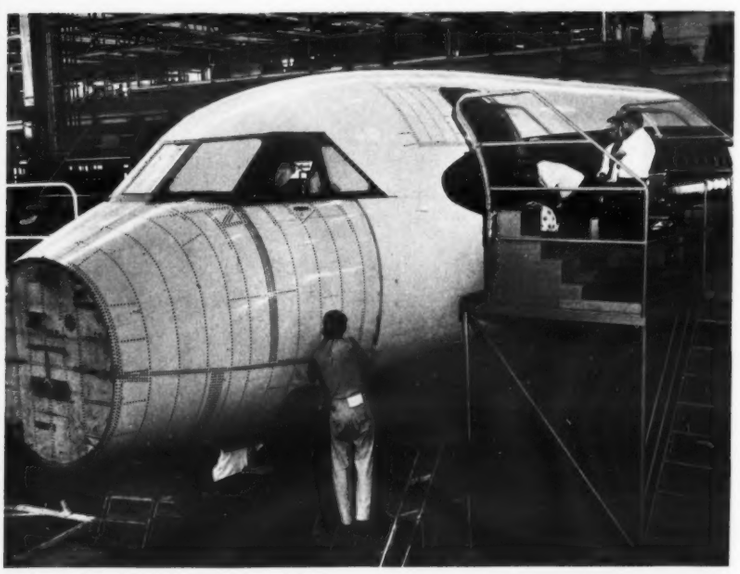
Mating the wing halves of the first prototype with the fuselage centre and rear at the Convair San Diego plant. The three-spar wing boxes serve as integral fuel tanks.

Exploded Diagram

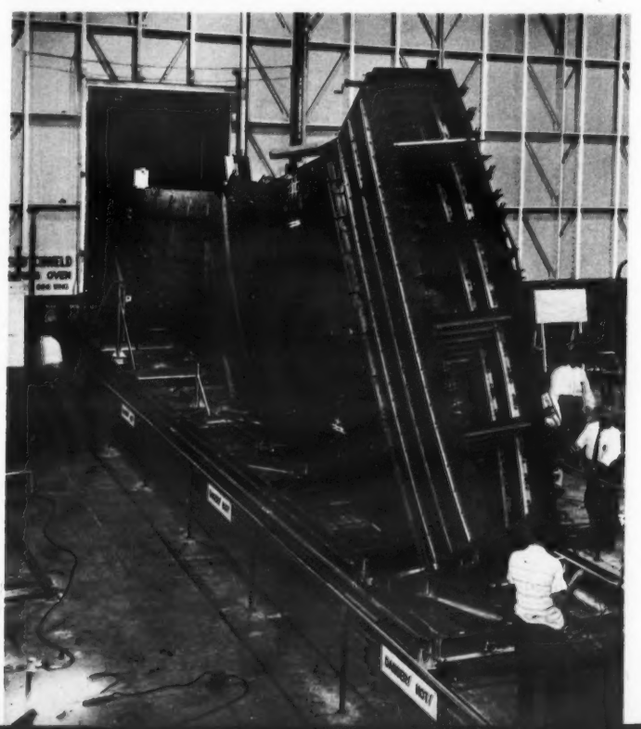


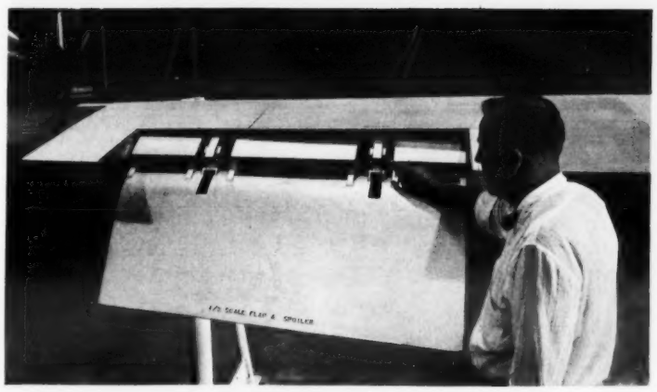
1 Plastic housing for weather radar
2 Pilots' seats with controls and instrument panel
3 Forward galley
4 Forward fuselage (with forward cargo compartment)
5 Starboard wing
6 Upper shell ("over-wing barrel") of centre fuselage (with emergency exits)
7 First-class seats
8 Galley and aft toilets
9 Rear fuselage (with rear cargo compartment)
10 Rudder unit
11 Tailplane (stabilizer operated by trim screw jack; spring tab controlled elevator)
12 Rear passenger door (with multiple locks)
13 Galley storage unit
14 Inboard double slotted flap and spoilers
15 Port aileron (with servo and trim tabs)
16 Outboard double-slotted flap and spoilers
17 Auxiliary spar and fairings
18 Rear fixed part of outboard wing
19 Three-spar wing box (and integral fuel tank)
20 Wing leading edge
21 Nose wheel unit (retracted forwards)
22 Front door (with multiple locks)
23 Cargo compartment door
24 Toilet
25 Lower (half) shell of centre fuselage ("underwing canoe")
26 Engine pylon and pod
27 Port main landing gear
28 Landing gear door
29 Air intake
30 CJ805-3 engine (with thrust reverser and silencer)

The forward fuselage of the first prototype (Ship 1) takes shape. In a later stage the antenna group for the weather radar (and its plastic housing) will be mounted in front of the pressure-tight forward bulkhead.



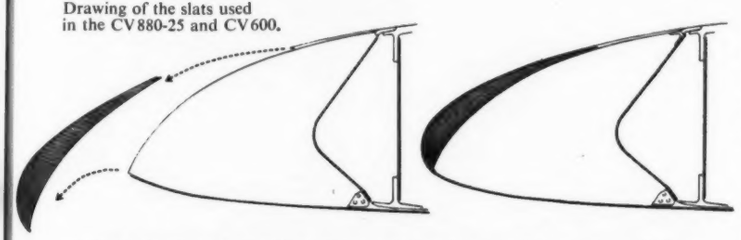
A fully riveted wing box for the CV880 is inserted in the giant electric curing oven (80 ft. × 20 ft. × 10 ft.) for the Scotchweld Adhesive Bonding process, where it is subjected to temperatures of 320°F (160°C) for one hour. The result is an absolutely – and permanently – leakproof finish.





Many months before manufacture of the first aircraft was begun all the technically vital details of the design were checked and finalized with the aid of mockups and models. Pictures here show only a small selection of these aids: half-size model of one of the four hydraulically operated double slotted flaps and spoilers, the latter in retracted position; mockup of the CV 880 crew station (with Convair Test Pilots D. P. Germeraad—left—and J. W. Knebel); port four-wheel main landing gear, with retraction mechanism; full-size (20 ft. long) fuselage section for tests of the cabin air conditioning system and sound-proofing.

Drawing of the slats used in the CV 880-25 and CV 600.



Thanks to its simple three-point suspension from pylons and its large clamshell doors, a complete engine change can be made in about 45 minutes.

triple windows and multiple-locked and bolted entrance doors withstand many times the safe load; the wings have three spars; the landing flaps incorporate safeguards against unequal extension; dual, partly independent pressurization and hydraulic systems; the hydraulic control boosters can be overridden by the pilot, etc., etc.

It would take too long here to list all the carefully considered details of this skilful design, though mention must still be made of one particularly striking and novel feature, namely the absolutely leakproof finish to the "integral" fuel tanks—i.e., the two wing boxes—by means of a new metal bonding process. In this treatment, known as Scotch-weld Adhesive Bonding, a thin plastic fabric is inserted at all joints between wing structure and skin, and riveted along with the latter. The fully riveted wing box is then placed in a giant curing oven, which melts, bonds and hardens the plastic (see picture). In addition to perfect sealing, this process naturally also still further raises the wing's overall strength. The method has been tested in practical operation on the Convair F-102 and F-106 all-weather fighters, to the full satisfaction of the USAF and the manufacturers, over the past few years.

Other technical details and performance figures can be taken from the accompanying drawings, payload/range diagrams and table. As regards the equipment of the new jet transports, it has already been decided that the very latest radio and navigation equipment, including weather radar and Doppler navigation radar, will be fitted.

The first five CV 880s are now in the final assembly stage at Convair's San Diego plant. Three of these aircraft (works numbers 1, 3 and 4) are destined for flight tests, and another (number 2) for static tests. Work number 1 will leave the final assembly shed in November this year, and by June 1960 monthly output is to be raised to at least six aircraft.

What's in the Air?

Extracts from Interavia Air Letter, *daily international news digest, in English, French and German.* *All rights reserved.*

Visit of Garrison Norton, the Assistant Secretary of the Navy for Air, to Fiat's Turin factories. Above, being welcomed by Professor Vittorio Valletta, President and Managing Director of Fiat. Centre of picture: General G. Pezzani, Chief of the 1st Territorial Air Zone. Below, visiting the Fiat Historical Aviation Museum at the Fiat plant.

AIR TRANSPORTATION

● **British Overseas Airways Corporation** on October 4th became the first airline to operate commercial jet services across the Atlantic. About two hours after a BOAC de Havilland *Comet 4* had left London for New York, another *Comet 4* took off from New York for a transatlantic flight in the opposite direction. The eastbound aircraft, carrying 28 passengers, including five paying passengers, and a crew of eight, set a new commercial record of 6 hours, 12 minutes for the trip to London, averaging 580 m.p.h. The other *Comet 4*, with 40 passengers and crew of eight, covered the distance from London to New York in the elapsed time of 10 hours, 20 minutes, including a refuelling stop of 1 hour and 10 minutes at Gander. Sir Gerard d'Erlanger, Chairman of BOAC, was among the passengers in the westbound aircraft. For the time being, the service will be flown once a week each way. Daily flights are expected to commence on December 1st. The *Comets* will have accommodation for 16 deluxe and 32 first-class passengers. Meanwhile, details of the permit granted by the Port of New York Authority to both BOAC and Pan American World Airways to fly the *Comet 4* and the Boeing 707 out of New York have been revealed. A statement from PONYA said specific restrictions on operating procedures would assure communities adjacent to the airport protection from intolerable aircraft noise: 1. all take-offs should be made seaward, and 2. the jet engines should be throttled back once a height of 1,200 ft. had been reached till the aircraft were well clear of land. No aircraft are to take-off between 10 p. m. and 7 a. m., except to the southwest. Night flights will be cancelled during the specified hours if weather does not permit use of the designated runway.

● **Scandinavian Airlines System** has been authorized by the U.S. Civil Aeronautics Board to pick up and land passengers at Anchorage, Alaska, on flights to and from Europe. Previously, SAS had been restricted at Anchorage to technical landings on the Europe-Tokyo route, without the right to embark or disembark passengers. The CAB, however, specifically denied SAS the right to pick up passengers, freight or mail at Anchorage for Tokyo or at Tokyo for Anchorage.

● **A Douglas DC-6B** of Transports Aériens Intercontinentaux on September 28th inaugurated the world's longest airline route, linking Paris with Tahiti, via Nouméa and Bora-Bora. This route of 14,910 miles is to be flown once weekly. The itinerary is as follows: Paris–Athens–Karachi–Saigon–Jakarta–Darwin–Brisbane–Nouméa–Nandi–Fiji–Bora-Bora. At Bora-Bora, passengers change to a Bermuda flying boat operated by TAI's subsidiary Réseau Aérien Interinsulaire. Start of the trip is from Paris Orly Airport on Sundays. At Tahiti airport a runway for jet aircraft is under construction; it should be completed by 1960.

Air Force General Edmond Jouhaud has succeeded General Max Gelée as France's Chief of the Air Staff. Born on April 2nd, 1905, Jouhaud attended the Saint-Cyr cadet school and joined the Air Force in 1926. Subsequently he held a number of senior posts in France, Tunisia, West Germany and the Far East. Recalled to France in 1955, Jouhaud was appointed head of the 5th Air Region, Algiers, in April 1957 and interservice deputy to the Commander-in-Chief in Algeria in July 1957.

● **Pan American World Airways** and National Airlines are seeking official approval of an agreement the two companies have concluded on the exchange of jet aircraft. The airlines also proposed a share-for-share exchange of 400,000 shares of each other's stock. Observers in Washington believe that the agreement may represent the first step towards a merger of the two companies.

At a ceremony marking the signature of an Austro-Bulgarian air transport agreement in Vienna, Tabso Managing Director Kiril Kirilov stated that the Bulgarian airline was interested in principle in British turboprop aircraft and accepted an invitation to take part in demonstration flights of the *Viscount* and *Britannia*. Left to right, Dr. Kudernatsch of the Austrian Federal Chancellery, Vienna; Dr. Günther, publisher of "Austria News", New York; Helmut Lerider, SAS Manager for Southeast Europe; Kirilov, Tabso Managing Director; Sepp Froeschl, Austrian Airlines Manager.

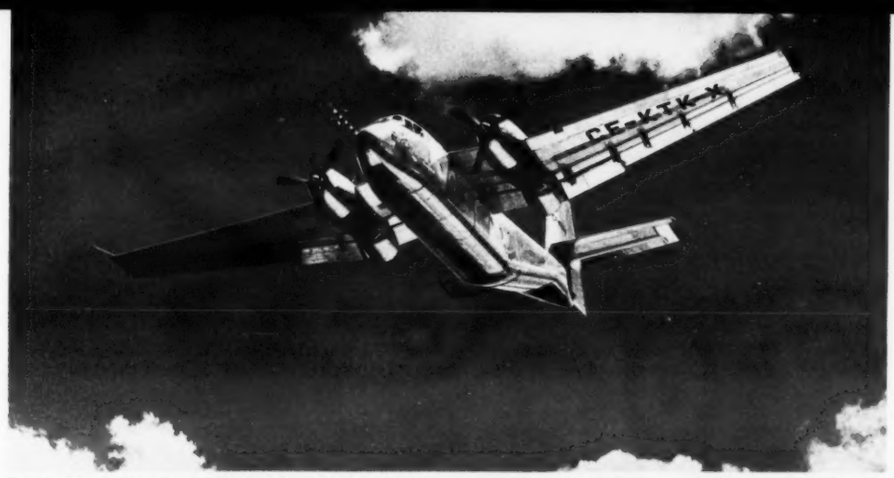
The Grumman *Gulfstream* executive aircraft, for 10 to 19 passengers, fitted with Rolls-Royce *Dart RDa.7/2* turboprops each of 2,105 e.s.h.p. The *Gulfstream* has a maximum cruising speed of at least 310 knots at 25,000 ft. (not, as erroneously reported in No. 9, 1958, 200 knots).

INDUSTRY

● **The British Defence Ministry** announced in mid-September 1958 that an initial order had been placed with Blackburn & General Aircraft Ltd. for 50 NA.39 naval strike aircraft for service with the Royal Navy. A Ministry spokesman indicated that several hundred more would be ordered later for the Royal Air Force. Industry sources in London believe that the NA.39 will also be produced for other NATO countries, including the United States. Designed as a carrier-borne naval strike aircraft, the NA.39 is powered by two de Havilland *Gyron Junior* jets. It made its first flight on April 30th, 1958, and was one of the highlights of this year's SBAC Show at Farnborough. The aircraft carries a crew of two and is intended mainly for low-level attacks with nuclear weapons. It will be capable of performing the strike role against targets at sea or on land, and of providing air support for land operations.

● **The Society of British Aircraft Constructors** has announced that its 20th Flying Display and Exhibition will be held at the Royal Aircraft Establishment, Farnborough, in the first full week of September 1959. As usual, the Monday (September 7th) will be a press preview and technicians' day.

● **The Avro CF-105** development programme as it now stands involves the building of 37 aircraft and an appropriate number of engines. This situation remains unchanged following the Canadian Government's decision to defer a final verdict on the future of the *Arrow* until next March. According to Sir Roy Dobson, Managing Director of the Hawker Siddeley Group and Chairman of A. V. Roe Canada Ltd., the programme calls for six CF-105s to be test flown by next March, at which time numbers 7, 8, 9 and 10 will be in flight test or on the production line. The third *Arrow* was successfully test flown on September 22nd.



De Havilland Aircraft of Canada Ltd.'s DHC-4 *Caribou* multi-purpose aircraft. The manufacturers hope to be able to deliver the first of the five *Caribous* ordered to date by the U.S. Army in February 1959. It is also planned to commence production of a first batch of twenty aircraft at the beginning of February 1959. A first civil version of the *Caribou* is scheduled for completion in March 1959.

The twin-jet Douglas A3D-2P carrier-borne photo-reconnaissance aircraft is now in mass production at the Douglas El Segundo, Calif. plant.

● **The National Aeronautics and Space Administration** on September 30th officially took over the 43-year-old National Advisory Committee for Aeronautics, under the Space Act. According to NASA Administrator T. Keith Glennan, the three main NACA laboratories will be renamed. The Langley Aeronautical Laboratory at Langley Field, Virginia, will be renamed the Langley Research Center. The name of Ames Aeronautical Laboratory, Moffett Field, California, will be changed to Ames Research Center, and the Lewis Flight Propulsion Laboratory, in Cleveland, Ohio, to the Lewis Research Center. No change of name is pending for the High Speed Flight Station, Edwards, California; Pilotless Aircraft Research Station, Wallops Island, Virginia; or the Plum Brook Research Reactor Facility, Sandusky, Ohio. NASA takes over NACA Headquarters in Washington.

At the same time, the 28 committees and subcommittees under the National Advisory Committee for Aeronautics will be reconstituted as advisory committees to the Administration until the end of this year, for the purpose of completing their work. Existing policies, regulations and similar matters governing NACA activities are to be continued in effect by the Administrator until changed or abolished. At September 30th, the NACA staff numbered more than 8,000 scientists, engineers, technicians and other employees. Its laboratory facilities were valued in excess of $300,000,000.

President Eisenhower transferred on October 1st America's moon rocket and various satellite and other rocket projects from the military to the new National Aeronautics and Space Administration. Projects transferred to NASA include the Navy's *Vanguard* earth satellite programme and the Army and Air Force lunar probes. NASA's budget for the year has been increased to $301,000,000, of which about $250,000,000 will be spent on space projects. Among the transferred projects were three being conducted by the Army to launch two balloon type earth satellites, one 12 ft. and the other 100 ft. in diameter, plus another cosmic ray *Explorer* satellite. NASA also took over research programmes in such areas as nuclear rocket engines, fluorine engines, and the 1,000,000 lb. thrust single chamber rocket engine.

● **The U.S. Army** has awarded Western Electric Co. a $135,000,000 fast development contract for the *Zeus* anti-missile system for defence against intercontinental ballistic missiles. It is also reported that the Mobile, Ala. district of the Army Engineers Corps has been selected to supervise planning for *Zeus* launching installations.

● **BMW Triebwerkbau GmbH,** Munich, and Bristol Aero Engines Ltd. announce that some time ago BMW acquired an option on licence production rights for the *Orpheus* jet engine. An agreement has now been negotiated whereby BMW Triebwerkbau GmbH is granted exclusive rights to manufacture and market the *Orpheus* jet engine in the German Federal Republic. The two companies will work together on further developments of the *Orpheus*.

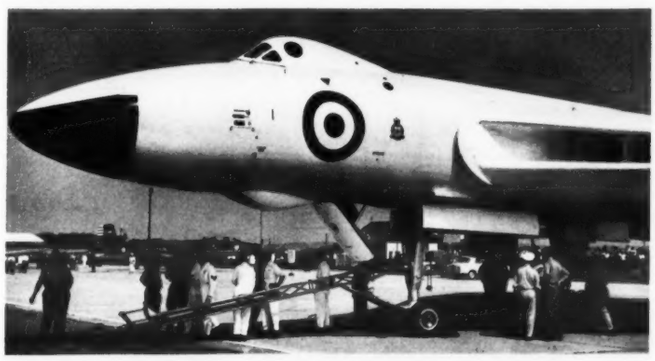
AIRCRAFT AND POWERPLANTS

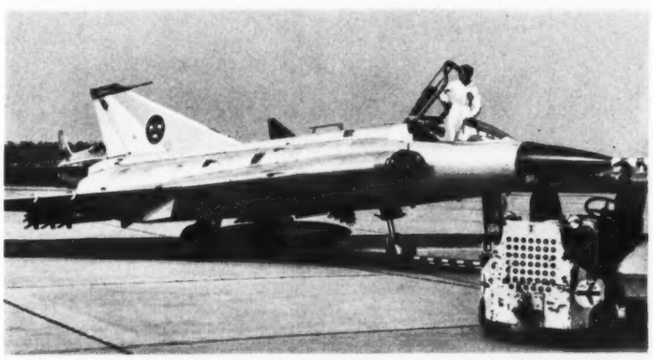
● First details have been announced of an afterburner version of the *Pratt & Whitney JT12* axial flow jet, designated JT12A-20. It is designed for high performance in the Mach 3 region. Maximum thrust is given as 3,900 lb.; military power 2,830 lb.; and engine weight 645 lb.

● *Piper Aircraft Corp.*, Lock Haven, Pa., has announced three 1959 versions of the *Tri-Pacer 160* four-seat sports and executive aircraft. All three versions, *Standard, Super Custom* and *Auto-Flite*, are fitted with a 160-h. p. Lycoming 0-320-B engine.

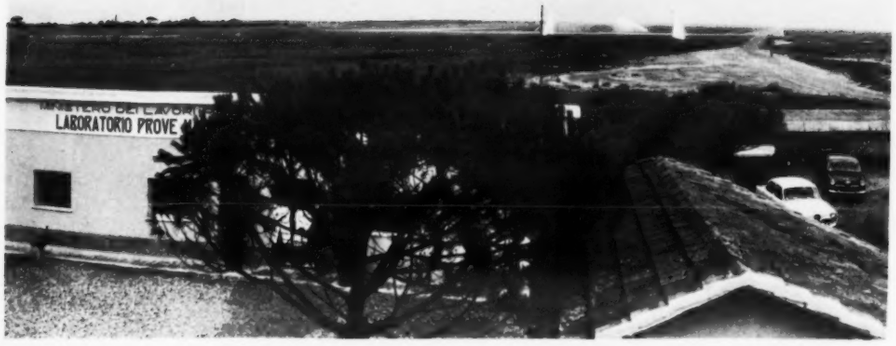
● *Hindustan Aircraft Private Ltd.*, Bangalore, commenced flight testing at the end of September on a lightweight aircraft which, under the designation *Pushpak*, could be used by Aero Clubs, the National Cadet Corps or police and ambulance services. No decision has yet been taken on the possibility of mass production of this aircraft.

● *North American Aviation* is reportedly giving serious consideration to production of a *triple-sonic transport* which would follow to a certain extent the B-70 lines.





Highlights of the International Air Show held at the beginning of September at Basle-Mulhouse Airport were, among other exhibits, Britain's Avro *Vulcan* medium-range delta-wing bomber (above left), France's SE.210 *Caravelle* medium-range jet transport (above right) and Sweden's Saab J35 *Draken* supersonic fighter (left). Right, Saab Chief Test Pilot Olow in conversation with Test Pilot Utterborn who demonstrated the *Draken*. Also on the programme were displays by four RCAF F-86 *Sabres*, formation acrobatics by the *Skyblazers* on USAF F-100s and demonstrations by the *Patrouille de France* on *Mystère IVs*. Also shown were a de Havilland *Comet Mk.2*, a Lockheed C-130 *Hercules* and a Nord 2501 *Noratlas*.



Giuseppe Togni, Minister for Public Works, recently briefed the Italian press on the progress being made in the construction work on Rome's new airport at Fiumicino (left). Right, the building site.

Sikorsky Aircraft Division of the United Aircraft Corporation recently completed the 100th S-56 helicopter. Left to right, Alex Sperber, Factory Manager, Michael E. Gluhareff, Engineering Manager, Lee S. Johnson, General Manager of the Sikorsky Aircraft Division, Ltd.; Col. Charles Wilkins, USAF representative at Sikorsky.

A French Air Force *Noratlas* was recently demonstrated to Haile Selassie, Emperor of Ethiopia.

● A new civil helicopter, the *Hiller 12E* with 305-h.p. Lycoming engine, is going into production at Hiller Aircraft Corp. Flight testing of the prototype began some time ago.

● A 25 percent increase in range has been announced for the *Lockheed Electra*. Extension of the *Electra's* range from 2,750 miles to 3,460 miles will be possible through provision for 900 U.S. gals more fuel. This includes two hours of reserve fuel. Also announced is an increase in take-off weight from 113,000 lb. to 116,000 lb. for future production models.

● The first major *N-156F* fuselage sections have been assembled at *Northrop Aircraft's* Hawthorne Division. Manufacturing work has been started on over 50 percent of the aircraft components, and first flight is scheduled for mid-1959.

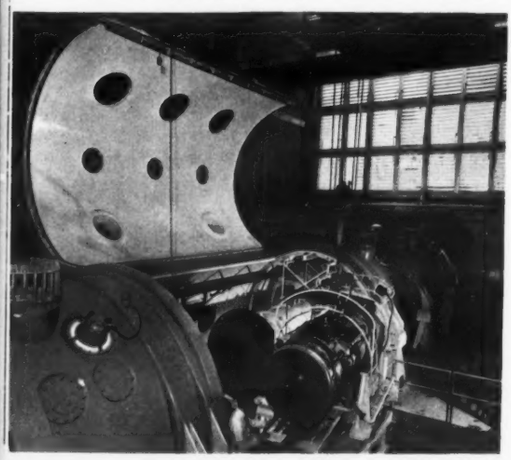
● *Costruzioni Aeronautiche Giovanni Agusta* announces a new helicopter to be constructed to a design by Zappata, and designated Type Z-101G. This is a 25-passenger model with a gross weight of 17,650 lb. All-metal construction, powered by three turbine units delivering a total of 3,000 h. p. Nose-wheel undercarriage with twin nose-wheel.

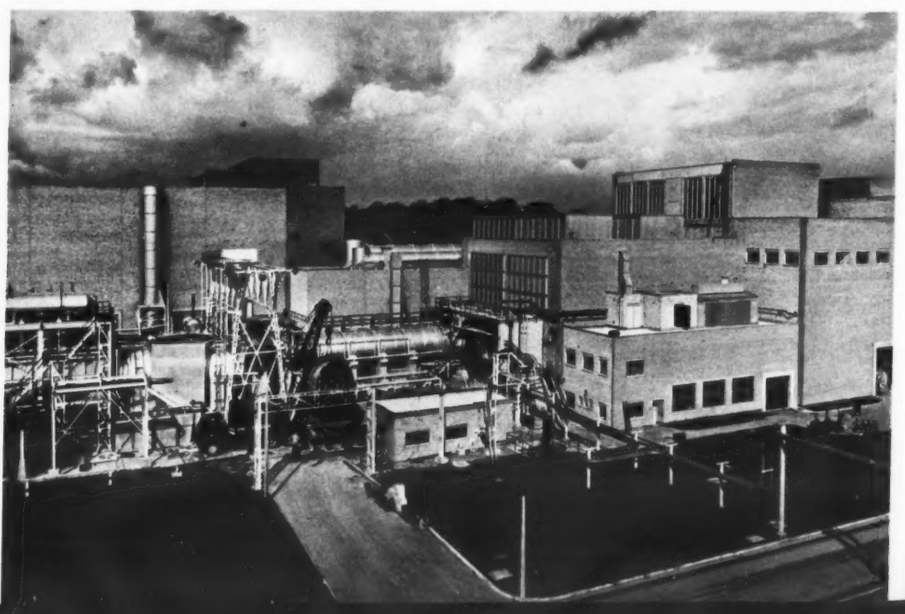
● First details of the projected *NEEFF F.400 Cobra* jet-powered two-seat sports and touring aircraft are now available. Powerplant one Turboméca *Marboré* of 880 lb. thrust. Metal and wood construction, with single spar one-piece wing with hydraulically operated landing flaps: semi-monocoque fuselage and conventional tail unit; hydraulically retractable nose-wheel undercarriage. Span 28 ft. 6½ in.; wing area 125.9 sq. ft.; weight equipped 1,540 lb.; gross weight 2,870 lb.; max. speed at 16,400 ft. altitude 379 m.p.h.; service ceiling 31,170 ft.; range at 14,760 ft. altitude, approx. 620 miles.

● Following a contract awarded to Nuclear Products—Erco Division of ACF Industries Inc. for the development and construction of a flight simulator for the *Republic F-105* all-weather figther, Republic now announces receipt of a contract valued at $16,410,000 for new versions of this aircraft—the F-105D and F-105E. At the moment, the F-105B version is in quantity production at Republic's Farmingdale factory. The F-105B is capable of carrying tactical A-weapons.

Goodyear Aircraft Corp. currently is conducting an aerodynamic study for the U.S. Army of a new concept, known as the *Convoplane*. The study envisages development of an aircraft that will accomplish the transition from forward flight to hovering or vertical flight, without rotating the aircraft or the power rotor axis, or using auxiliary propulsive systems. Principle of operation of the *Convoplane* achieves transition from forward to vertical flight by changing the direction of air flow (cf. drawing).

The new Rolls-Royce Powerplant Research Laboratory was recently opened officially. Left, an Altitude Test Plant with *Conway* by-pass engine; right, part of the testing equipment.





SEASLUG

SHIP-TO-AIR MISSILE WITH A SHARPSHOOTING RECORD

The Seaslug is the Royal Navy's first ship-to-air missile. Launched from the pitching, tossing deck of its trial ship, H.M.S. Girdle Ness, it has proved its accuracy under the most trying conditions. Although the Seaslug does not need to score a hit to destroy its target, the test vehicle, without a warhead, has made direct strikes frequently on target aircraft. With long range radar, it can engage bombers up to the maximum height at which modern aircraft can fly. The firing crew is far smaller than the crew of a gun turret in a major warship.

Powered by a solid fuel sustainer motor and four boosts, the Seaslug has been designed and constructed by AWA in conjunction with the Sperry Gyroscope Co. Ltd., and G.E.C. Ltd.

SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT LTD., BAGINTON, COVENTRY

MEMBER OF THE HAWKER SIDDELEY GROUP

MANOEUVRABILITY

RADIUS OF TURN
2½ n.m. (4.5 km.)
at 45,000 ft. (13,700m.)
—THE TIGHTEST TURN
OF ANY ADVANCED
AIRCRAFT

PERFORMANCE

CLIMB	45,000 ft. (13,700m.) IN UNDER FIVE MINUTES from Brakes-Off: at operational weight
RADIUS OF ACTION	500 n.m. (950 km.)
LEVEL SPEED	M.98
TAKE-OFF	400 YARDS
LANDING	600 YARDS
ARMAMENT	2,200 lb. (1,000 kg.) rockets or bombs plus two 30mm. guns

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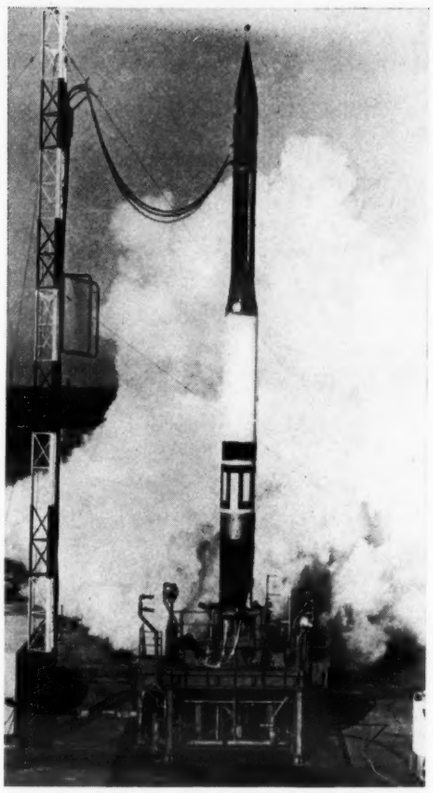
Solid-Propellant Rockets and Space Flight

by Kurt R. Stehling, Head, Vanguard Rocket Group, Naval Research Laboratory, Washington



Ground test of a *Vanguard* satellite rocket with solid-propellant third stage.

All the U.S. satellites to date were projected into their orbits by solid-propellant rockets which formed the last stage or stages of a satellite launching vehicle. The interesting question then arises: were solid-propellant rockets used because there were no other vehicles available, or was there some peculiar virtue which made their use attractive ?

The answer is, that it was a *mixture* of these motivations which gave the solid propellants such an important role. Scanning the unclassified published domain of U.S. liquid-propellant rocketry shows that no small liquid rocket units were available, with the proper performance, for use as the last stage of a satellite launch vehicle. With no liquid-propellant rocketry available, the U.S. satellite effort then depended on the development and usage of solids. Both the *Vanguard* and the *Explorer* satellite projects are, of course, the best examples of the usage of solids.

The choice fell then to the solid for the following reasons:

a) Because of the limited funds available and also limited hardware development time, it was decided to make the third stage of the *Vanguard* an unguided one and capable of adding at least half of the required incremental orbital velocity. With no guidance, spin stability for an accurate flight path at the desired injection angle was necessary. While a liquid can be spin-stabilized, a solid is a much more promising device for this purpose. The spinning reduced the perturbing effect of small thrust asymmetries.

(b) Absolute reliability of ignition and starting of the final stage are required. Again a liquid rocket, particularly one filled with hypergolic propellants, most likely will ignite with great reliability in vacuum. However, a lack of information on liquid starting characteristics in vacuum led again to the solids which were presumed certain to ignite, particularly if the rocket is sealed at atmospheric pressure by a throat plug.

(c) The third stage *carrying capability* of the launch vehicle permitted only a rocket weighing some five to six hundred pounds. No suitable liquid unit was available and there was no possibility of one being developed in under two years. The third stage was developed by the Grand Central Rocket Company in the brief space of nine months and was fired successfully for the first time in Test Vehicle I in early 1957.

(d) It was also realized that a better vehicle performance could be obtained with a small size solid rocket than with a liquid, even if the time had been available to develop a liquid rocket vehicle.

In the early design of the *Vanguard* vehicle, the Martin Company and the Naval Research Laboratory considered various combinations of liquids and solids for the satellite launch vehicle. The present combination of a first stage burning kerosene and oxygen and the second stage, " dimazine " and nitric acid, with a third stage solid were considered as the most practical combination of hardware to be developed within the time limit available for the IGY mission of the *Vanguard*. The *Vanguard* third stage has performed very well and within specifications. It was ready on time for the test firing of the first two-stage vehicle and has never failed to ignite when the ignition signal was applied to the igniter leads. No signs of combustion instability were noted.

Finally, the successful Army *Explorer* satellites were, of course, also launched by combinations of eleven, three and one solid rockets. The ABMA group, like the *Vanguard* group, analyzed the various combinations and possibilities of rockets and finally ended up with the very reliable *Jupiter C* (formerly *Redstone*) booster with the equally reliable JPL rockets (Jet Propulsion Laboratory, California Institute of Technology). The sharp pitch-over trajectory of the *Jupiter* booster and the high incremental velocity needed for the last stages dictated the use of solids. Even though the solid cluster may seem complicated, it has performed with great reliability except in the second firing. It is my understanding that there was some question of ignition trouble with the solids. However, within the limitations of the equipment, it seems that the *Explorer* firings have been most successful and, while oddly enough a solid combination was not as reliable (in firing No. 2) as the much more complicated liquid, it has performed well and lived up to the expectations of the ABMA group. The Air Force lunar vehicle called *Thor-Able* has been publicly announced as a *Thor* first stage, a *Vanguard* second stage and a third-stage solid rocket.

While the Soviet authorities have not released any details of their launch vehicles, it seems rather obvious that they use very large liquid rockets, perhaps two stages based on the German A9-A10 concept. It is likely that the Soviets use combinations of small solids for separation and/or spin purposes or even to give final incremental " kicks " to the last stage.

*

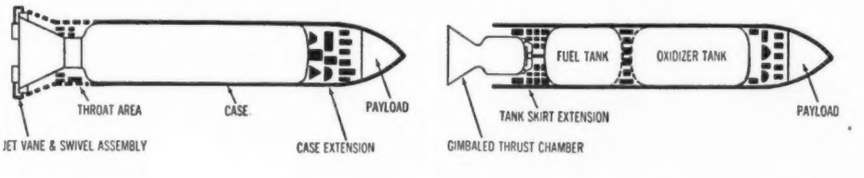
In several areas in U.S. rocketry the solid has proven outstanding and most reliable and also fairly cheap. Here are some uses which have given the solid a permanent spot in high altitude and other research in the U.S., and I believe also in Britain, France, Japan, and one presumes, Russia.

In several papers a few years ago I showed a number of schemes for launching satellites and vehicles from balloons with solid propellant rockets, which usually have a shorter burning time, with the total impulse compressed into a much narrower spectrum than a liquid rocket, and therefore have high air drag but low *g.t* losses [1]. In late 1957, the USAF with the Aeronutronics Corporation as contractor, launched several very high altitude vehicles from islands

[1] The *g. t.* losses are represented by the second expression in the well known equation for rocket velocity:

$$V = c \ln \frac{m_0}{m_1} - gt - V_{drag}$$

Comparison of accessories installations in a solid-propellant and a liquid-propellant rocket.



in the Pacific Ocean. These *Farside* combinations of clusters of solid rockets were hung from a large balloon and fired at high altitude. Some reports say altitudes of almost 4,000 miles were reached. Leaving aside for a moment the difficulties of clustering and balloon suspension of solid rockets, this was and still is a cheap method of launching small payloads (50 lb.) from the low drag environment of high altitude, above 75,000 ft. The "rockoon" (rocket balloon) scheme, first begun at the University of Iowa, has been rather successful and has served for some years to fill a large part of the high altitude research program for universities who traditionally are handicapped by limited budgets. If the payload of a similar combination were reduced, to say about 4 lb., and existing solid-propellant rockets such as the *Nike Zeus* were used, it would be possible to reach an escape velocity of about 36,000 ft. per second at relatively low cost.

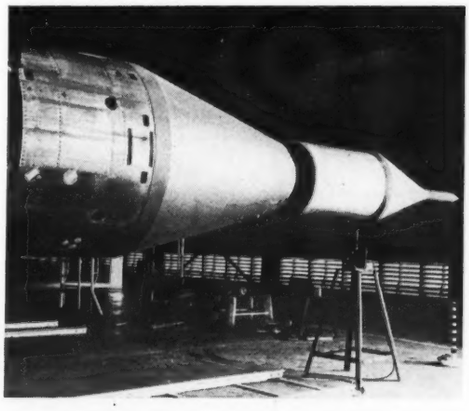
The *X-17 test vehicle* has been very successful and has reached altitudes of over 500 miles with combinations of solid rocket stages. This was done for various purposes including re-entry information, and also was done cheaply as compared with large liquid vehicles.

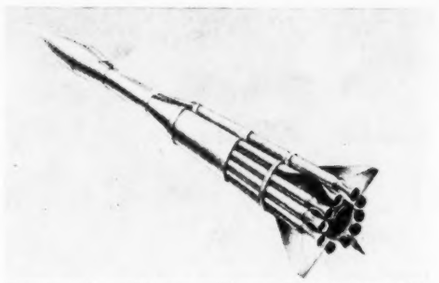
A rather minor but still important use of solids has been for retro-force and spin-up (and separation) for the *Vanguard* vehicle. The second stage of the *Vanguard* vehicle near the end of its coasting time and when pointed into the orbit flight path is suddenly slowed down by small solid propellant rockets firing for one second; this permits the third stage to slip out of its housing and well away from the second stage before it ignites and burns. At the same time, the third stage has been spun on a turntable by similar small solid-propellant rockets. This scheme has worked at all times when the signal reached the solid rockets, and malfunctions have been only in the area of electrical connections and so on.

Another *Vanguard* use is the generation of solid-propellant-helium gases in the second stage helium pressure reservoir sphere. It was shown during the early vehicle design by Martin and Aerojet that the second stage would be too heavy if it depended on helium alone for pressurization. Therefore a solid charge was inserted into the sphere and added to the total amount of hot gas charge available for pressurization. Thus by chemical means a good deal of structural weight was saved.

*

The nozzle of this Aerojet solid-propellant rocket motor takes on giant proportions compared with the first take-off rocket for aircraft dating from 1941 (in F.S. Miller's right hand).





Drawing of a multi-stage solid-propellant rocket consisting of an *Honest John* artillery rocket and ten boosters of undisclosed type arranged in a circle around the motor case; project designation *Father John*.

Thus in the rather limited area of high altitude space flight and especially orbital flight, we can see several advantages of solid-propellant rocket motors:

(a) simplicity;

(b) spin capability;

(c) very small size for spinning and separation and in confined areas;

(d) instant readiness, with short ignition delay and usually rapid shutdown decay;

(e) high mass ratios for small units as for the *Vanguard* use; mass ratios transcending 0.9 at the moment do not seem easily possible with the more complicated liquid propellants;

A Jet Propulsion Laboratory solid-propellant rocket forms the final stage of the *Jupiter C* satellite vehicle. Top picture shows the shell-shaped *Explorer* satellite being placed on the final stage. *Below*, the nose of a *Jupiter C* rocket with rotating drum to take the second, third and fourth stages.

(f) medium to high performance capability in terms of exhaust velocity and even specific impulse; the solids, however, are still some distance removed from liquid rocket combustion efficiencies;

(g) a rather good growth potential with the use of new materials such as fiberglass and light alloys and metal-enriched solid grains.

Since the solids have done so well in the U.S. space flight effort, may they not have a continued application and a growing participation in future space enterprises ? The *Minuteman*, *Pershing*, and *Polaris* rockets have been openly announced for military purposes of various kinds. With these rockets being developed, it is quite likely that some space application may be found for them if they are not monopolized for military reasons. These examples of solids as large primary powerplants for medium sized vehicles could surely be used to project small payloads into orbits or even to escape velocity. At the same time, with combinations of various small rockets, it will be possible to do some advanced forms of high altitude research to several earth radii.

*

What other possibilities exist for using solids as prime movers for lunar rockets, say, whose payloads are beyond one ton, or even for rockets beyond lunar capability ? For such advanced missions, the *limitations of solids* become apparent and even most restrictive. Here are some of these limitations which will hinder the use of solids for advanced space missions:

Limited burning time : Very few solids that I know, in the unclassified area, are capable of burning beyond one minute. Although the solid flame usually is a reducing flame, the erosion of throat, entrance to the throat and the nozzle region is a serious problem when burning times extend beyond a minute or so. If a solid's burning time capability is to be changed, it is not easy to adjust grain configuration, case and throat size and, as burning time increases, provide adequate heat capacity in the exit areas. If burning times beyond one minute are required, then some scheme of throat cooling, perhaps by sweat or film bleeding of an extraneous liquid, may be necessary. If the burning time is kept under one minute, then for any given advanced mission for a very high thrust rating (and high total impulse), acceleration rates may be very high, requiring the final stages to be overdesigned in order to withstand this acceleration and therefore resulting in a reduced mass ratio.

Difficulty of guidance : Large liquid rockets are, of course, usually controlled these days by gimbaling the entire rocket and thrust chamber. Since the thrust chamber is independent of the other plumbing and hardware (by the use of flexible hose connections), the thrust chamber can be moved in the proper direction to give pitch and yaw control, and in many cases the propellant decomposition products of the gas generator can be used to provide roll control through small roll jets, as is done in the *Vanguard* stage one. In a solid, jet vanes may be used in the exhaust, but these suffer severely from the hot gases when burning times are extended beyond one minute. It may be possible to swivel the nozzle; there then arises the possibility of shock formation in the nozzle and of heat transfer excesses in its necessarily complicated

joint. Furthermore, roll control would then still have to be provided by some auxiliary gas jet.

Limited thrust : It is axiomatic that, for a large payload for any given mission, a large thrust is necessary; it has been openly announced in the U.S. that a one-million-pound liquid rocket engine will be developed. Even assuming extraordinarily high specific impulses and mass ratios, it is still difficult to conceive a much lower thrust system capable of doing any serious space mission—by " serious " is meant here the projection of a payload above one ton to the moon's surface. The writer cannot say whether a one-million-pound solid propelled engine will ever be developed in the U.S.; it seems, however, from first principles of solid-propellant design that it would be a remarkably difficult undertaking to build a solid-propellant powerplant of that size with a burning time of say two minutes. There are (among others) tremendous problems of grain casting, curing and bonding into a proper case.

Temperature sensitivity : Even in the environment of an earth-based satellite launch area, it is difficult to maintain the propellants at their specified temperature. Whereas liquid propellants can usually suffer a wide temperature change without prejudice to the combustion process, solid propellants have as a rule rather narrow temperature limits, with cracking, case separation and other mechanical changes and some loss of performance occurring at temperatures of, say, below 50° Fahrenheit. It is perhaps possible to pick a proper environment for the launching, but it is sometimes impossible to pick particular temperatures during shipment. At any rate, with a narrow limitation of temperature for a high-performance large solid, it is necessary to examine the solid-propellant charge and establish its soundness before firing. Again, in a very large unit this is not a simple matter.

Power generation : Most large rocket vehicles, and particularly those for space missions, would require secondary power sources for hydraulic and electrical apparatus. A solid-propellant rocket having no gas turbine pump would have no capability of providing such power, and this would have to be supplied by an auxiliary power source which again means some extra complexity and loss of mass-ratio.

Combustion instability : This old friend of the rocket business (I call it friend since it has provided so many research contracts for scientists) is ever-present in solid-propellant rockets, and like instability in liquids is not easily cured. Indeed sometimes the most expensive problem in a solid-propellant rocket is its instability or resonance.

Doubtful start-stop ability : For some *manned space* vehicle projects control of the rocket engine's combustion is necessary, and the pilot must have some means of shutting his engine down for coasting or for safety purposes. At present there seems to be no easily available method for doing this in solids other than blowing out the entire nozzle or bleeding the rocket gases out of side ports. This scheme has possibilities but requires specially designed heat resistant hardware and symmetric venting of the gases to prevent undesired vehicle perturbation. I do not know of any simple way to *re-start* a solid. On the other hand, occasionally a solid will explode for unknown reasons and when it does explode it goes very quickly. While the thrust chamber of a liquid rocket may also explode, the pilot might still have time to eject. Some thrust control, i.e., cut-off and re-ignition, has been announced from time to time for experimental small rockets; also, by the design of differentially burning grains, it is possible to do some thrust programming and indeed even achieve a variable thrust and constant acceleration pattern. However, these schemes are laboratory ones only and may take many years of development for a successful application.

The Lockheed X-17 multi-stage research rocket was powered solely by solid-propellant motors. Even the rockets used to produce spin (seen in the centre of the vehicle) used solid propellant.

Limitation on combustion efficiency or exhaust velocity : It is perhaps possible to achieve, within the next two or three years, specific impulses exceeding 250 seconds by some considerable margin with new solid grains. However, I doubt whether the high exhaust velocity or specific impulse (at a given chamber pressure and expansion ratio) of advanced liquids will ever be reached in solids. For instance, the theoretical specific impulse of a fluorine-hydrazine mixture in vacuum, at 500 p.s.i. chamber pressure, approaches 400 seconds. This presently is far beyond even the theoretical capability of composite or double-base grains. Incidentally, this specific impulse, although desirable, is not as important as a high mass ratio, especially in very large rockets. One wonders also whether a solid's propellant-to-total weight ratio is favorable, as compared to liquids, for very large rockets, considering the heavy case used as the structure. If a high specific impulse is to be achieved with a solid and a good burning rate (the two tend to be associated), then a high chamber pressure is necessary. Even though the propellant contributes something to the retaining of the chamber pressure, the *case* must take most of the load and therefore must be substantial in strength. In a very large liquid rocket the tanks must also be pressurized, but if pumps are used, as they would be for big vehicles, the tank pressures would be far below that of a solid propellant rocket. Since the ratio of tank-to-auxiliary-component weight (thrust chamber, pumps, valves, etc.) decreases very considerably for large vehicles, the tank weights become almost all-important.

Short burning time : In a liquid vehicle, if the burning time has to be adjusted, one need only change tank domes, as the regeneratively cooled rocket thrust chamber, once having reached thermal stability, can burn for a period considerably longer than its normally specified period. As stated before, a solid's thrust or burning time can be varied only by a redesign of the grain charge and the port and throat areas. An interesting consideration is that storage space for auxiliary components is hard to find in a solid rocket, since there is no space between tanks, and the throat and nozzle areas do not leave much. The grain case must then be extended, and space for controls provided for in front of the rocket.

Conclusion

Considering the various factors above, it can be reasonably predicted that the use of solid rockets for various space flight missions will be limited to small orbital and lunar payloads. The solid will shine most in areas where simple control requirements exist, and either short, high energy bursts of thrust or a high mass ratio for a small vehicle are needed.

The great simplicity of the solid, with its absence of valves and flow controls, may be used for such things as retro and spinning rockets and perhaps as the final unit of a lunar vehicle which must land on the surface without breakup. It may be desirable then to have a solid for such a purpose provided that it withstands space radiation and low ambient temperatures. It may be possible to obviate some of the temperature problems of solids, particularly those used for the above-mentioned braking purposes, if the propellant could be heated or kept at constant temperature electrically, say by a conducting case or even by a partially conducting propellant or one having embedded in it fine conducting wires. And finally, another interesting use of solids is for the limited objectives of circular-orbital flight. Here, they may be used as the final " kick " scheme for placing the payload into a circular orbit.

Air Traffic Control and Autonavigators

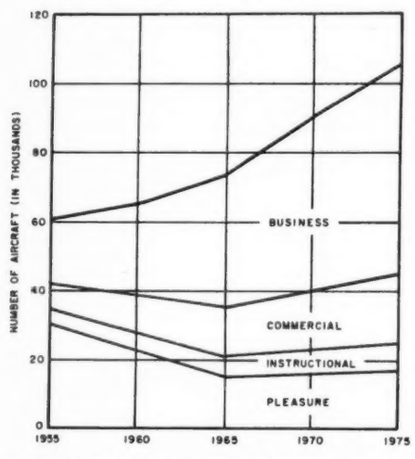
By Hans Giesecke, Airways Modernization Board, Washington, D.C., USA

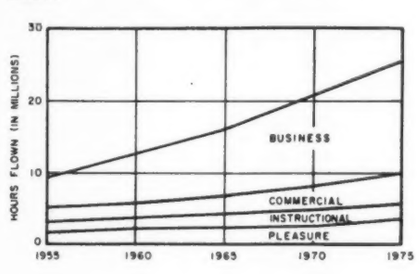
Most writings on United States air traffic emphasize the fact that scheduled airline and military operations in the USA experience delays in instrument weather and that mid-air collisions occur which might have been prevented by a better air traffic control system.

It is less common knowledge, however, that a large fraction of the close to 90,000 aircraft registered in the USA under the summary designation of General Aviation are owned by private individuals or private business companies.

As indicated in *figures 1 and 2*, this number and their activity are rapidly growing. It is known that in instrument weather most of these aircraft are not widely utilized, although they are quite well instrumented. Thus, a large source of economic strength will remain untapped unless modernization of air traffic control is achieved.

It can hardly be lack of effort or scientific interest that leaves us with this unpleasant and much discussed situation. The international sum total of research and development effort applied to air traffic control and navigation has always been large. It may be, however, that we fail to recognize mistakes we are committing with respect to total systems planning and that we should search for new methods of better understanding the evolutionary growth of such a unique large scale complex as represented by an air traffic system. To find such methods, it is mandatory that a single agency have the responsibility for integrating all efforts into one system.





Figs. 1 and 2. Probable development of private flying in the United States up to 1975. Upper graph shows the number of aircraft (in thousands), lower graph the number of flying hours (in millions), in both cases according to type of activity.

In the USA, the *Airways Modernization Board*[1] was recently established by the United States Congress. This office now has sole responsibility for directing all Government sponsored research and development effort for civil and military air traffic control and navigation. Thus, a long evolution towards concentration has been brought to a conclusion, and the management of research and development has been unified. Some of the research programs of this office are aimed at the discovery of better ways of system engineering, applicable to the modernization of air traffic control.

A good idea of the difficulty of the task of modernizing air traffic in the USA can be obtained by studying *figures 3 to 7*. These are some of the results obtained from investigations conducted in 1957 under the direction of Mr. *Edward P. Curtis*, Special Assistant to the President of the USA. It can easily be seen from these charts and pictures that the problem of handling such volumes of traffic in any weather cannot be solved merely by increasing our present navigation, communication or radar facilities, controller displays, etc., or even by the introduction of new techniques with better accuracies or better applicability to automation. Instead, an all-out and well organized re-examination must be made of the validity of present procedures, methods, regulations, integration of equipment, and interplay between machines and human operators. Furthermore this must be undertaken in such a manner that the effectiveness of proposed or planned changes can be measured and predicted with respect to their influence on the over-all system performance.

*

Before the future impact of the *introduction of self-contained navigation systems* can be predicted, a valid measure of effectiveness in the over-all air traffic picture must be available. Since this has not yet been developed in a generally acceptable form, I shall list a number of concepts which could be used to examine the desirability of the possible applications of self-contained systems which I describe later. I suggest using these concepts as preliminary yardsticks, and hope that I have selected the group of concepts which has the best chance of being acceptable to all concerned.

1. In the past there has been no requirement to actively control air traffic from the ground under VFR conditions. This may lead to the belief that an efficient IFR system should in principle be possible if we merely invent suitable airborne equipment. On this point I should like to state:

- Present VFR procedures have already become insufficiently safe not only because of higher speeds but also because of the high densities of air traffic.
- Air-to-air collision prevention equipment, even if it were technically and economically feasible, cannot solve the problem of expediting the flow of traffic. This must be accomplished by a central agency observing the movement of aircraft from the outside. Hence, a ground based traffic control system is essential.

2. The entire airspace must be covered by air traffic control. Restriction to geographically fixed airlanes accelerates saturation of airspace. Also, fixed airlanes are unsuitable for most military operations.

3. A uniform solution applicable to all types of aircraft and to all geographical areas of air traffic is economically wasteful.

4. New items to be operationally introduced, be they equipment, procedures, or regulations, will necessarily obtain the status of standards and hence will have a long life. Therefore, thorough analysis of all technical, operational, and economic aspects is necessary to avoid pitfalls.

5. The basic order of traffic, even in the vicinity of airfields, should be laid down in standard operational procedures. That system which requires the least additional control from control centers is the most desirable solution from the pilot's viewpoint, and, very probably, also the most economic system.

With these concepts in mind, I shall now discuss self-contained navigation systems. None of the present equipments of self-contained navigation systems has been specifically developed for air traffic control applications. They are mostly the results of military requirements, and the designers have attempted to find purely self-contained solutions. They were not required to seek

[1] In the meantime the Airways Modernization Board has been taken over by the recently formed Federal Aviation Agency. — Cf. *Interavia*, No. 10, 1958, page 1001. — Ed.

possible applications of ground cooperating techniques.

There are three general types of self-contained automatic navigator : the so-called dead-reckoners, the Doppler navigators, and the inertial systems. Only those which deliver course and distance information to arbitrarily selectable geographical points should be considered, after some redesign, for application in air traffic control.

Conservatively estimated performance characteristics of possible new designs are about as follows:

- *Dead - reckoners :* Maximum position errors smaller than 10 percent of distance traveled, for a weight of less than 20 pounds.
- *Doppler Systems :* Maximum position errors smaller than 3 percent of distance traveled, for a weight of less than 110 pounds.
- *Inertial Systems :* Maximum position errors less than 6 n.m. per hour traveled, for weights which are probably less than 110 pounds.

It is worthwhile to note that the probability of reaching a desired destination with these positional accuracies (or the equivalent in time-of-arrival if some speed control is applicable) and under actual operational conditions is very high, even with less skilled pilots. This is true for two reasons:

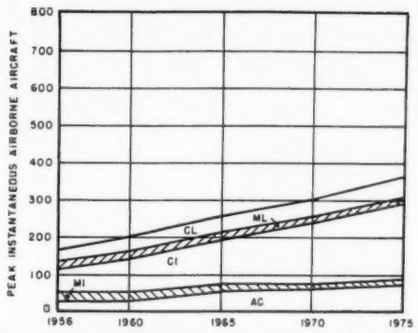
— Output is direct course and distance information;

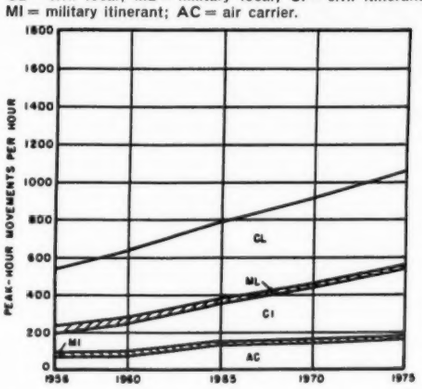
— Inflight operation is simple, thus reducing the probability of human error.

In considering the weights of the equipment, it should be pointed out, especially in the case of inertial systems, that with the introduction of this equipment other standard items in the aircraft can be either replaced or redesigned to smaller weights.

You may note that I use more conservative figures on performance than are usually found in literature. However, I should like to emphasize that I have in mind designs eventually applicable to mass production and to the large fleet of privately-owned, business-type aircraft.

Figures 8 and 9, which were compiled by *Mr. Walter Fried*, Dayton, Ohio, Institute of





Figs. 3 and 4. Probable development of peak traffic in the New York area (circle of 50 miles radius) up to 1975. *Top*, the number of aircraft simultaneously in the air; *bottom*, the number of hourly aircraft movements (take-off and landings). CL = civil local; ML = military local; CI = civil itinerant; MI = military itinerant; AC = air carrier.

Navigation, show the state of the art in Doppler navigators. Note the flattening of the performance trends, indicating that a certain stability of progress has been reached, so that further postponement of introduction does not seem justifiable.

*

I, nevertheless, doubt that standardization of any one of the presently available designs would be desirable. *I believe that redesigns are necessary which integrate more economically with other equipment in the aircraft and in the over-all air traffic control system.* Fail-safety and economy make this desirable. This will be clear from the following paragraphs which deal with potential uses of auto-navigators.

1. *Instrument panel :* In the past, whenever the electronic engineer invented a new system, he also invented new instruments and managed to find space for them in the cockpit. Sadly enough, many of us are still not disturbed by this procedure. Over-all performance of the average pilot has very probably decreased because of confusion, and the extremely valuable visibility of the outside world has become marginal in many modern aircraft. With the introduction of automatic navigators, however, there is a chance of standardizing the instrument panel for long periods ahead. Any future invention would be connected to the computer part of the autonavigator and not to new instruments. The only change affecting the pilot would then be more accurate or more reliable information on his standard instrument panel. This, of course, also applies to the possibility of selecting a standard coordinate system for air navigation and traffic control. It might well be that eventually we will return to some sort of latitude and longitude system.

2. *Combination of self-contained systems and ground aids :* Here I propose to reserve the name *autonavigator* for this combination. I suspect that such bastard combinations will have the best economic future and soon outclass the thoroughbreds.

We occasionally treat ground supported navigation aids as if they were actual navigation systems furnishing course and distance information. However, none of our systems, with the exception of the radio compass, can be flown without a magnetic compass or gyroscope.

It seems to me that we are wasting quite a bit of bandwidth just to determine proper heading. Instead, let me consider a combination of, for instance, a VORTAC receiver and a dead-reckoner designed from scratch to be one unit. It is then conceivable that we need the VORTAC information only intermittently, i.e., our ground network could be less dense in unpopulated areas. Or we could time-share frequency channels, thus reducing the number of channels required. Furthermore, allocation of specific channels to specific altitudes and automatic channel selection by the altimeter would free the pilot for other duties.

3. Another field of possible influence concerns *air-to-ground and point-to-point communication.* Automation of two-way air-to-

Fig. 5. Transcription of radar display observed in the New York terminal area at 10.30 a.m., on July 14th, 1956. There are 123 aircraft on the display, 85 per cent of them below 10,000 feet altitude.

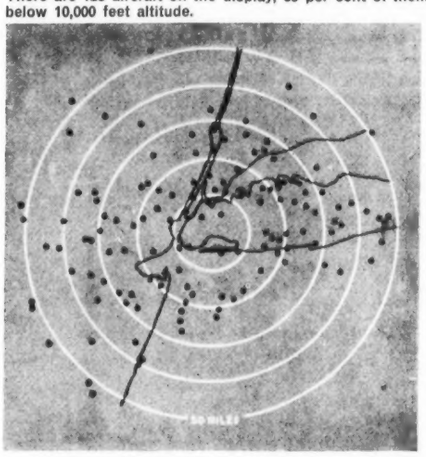


Fig. 6. Possible distribution of forecast 1975 airborne aircraft in the New York area. About 350 aircraft are shown.

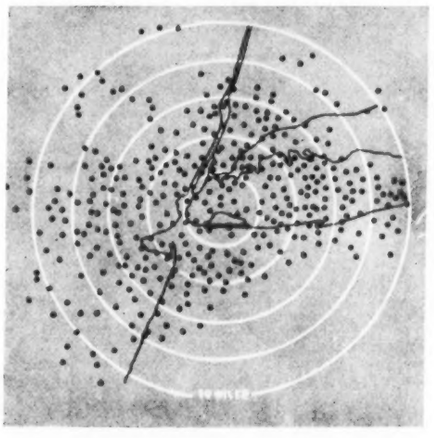
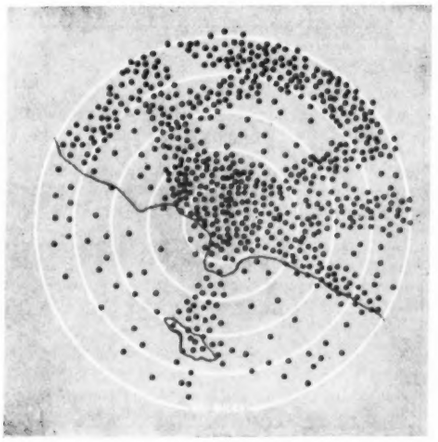


Fig. 7. Possible distribution of forecast 1975 airborne aircraft in the Los Angeles area. About 730 aircraft are shown.



ground communication has long been desired, but has not yet been put into effect, mainly because of the complexity of equipment. With the introduction of autonavigation, prediction of future position in space and time and adherence to a flight plan, cleared to any destination, will be so much more reliable that the rate of information flow for air traffic control purposes can be considerably reduced. In the extreme, theoretical, case where each aircraft is instrumented so that it can accurately adhere to a scheduled flight plan cleared before take-off, any additional communication would be superfluous. Although this is not practical, improvements in this direction are feasible. Industry proposals for automatic communication equipment which begin to look very promising as regards simplicity, cost, weight, bulk, and capability of progressive introduction, have been received in the USA. Most of these suggestions consider utilization of presently installed equipment, propose small supplementary attachments to the airborne equipment, and are based on a *ground controlled selective interrogation scheme*. Reporting of position and flight plans would be in the form of telemetering the autonavigator data on request from the ground.

4. It is quite obvious that safety considerations make *additional independent means of position determination* desirable or even essential. However, on the statistical average, again only intermittent checks are required if a high percentage of aircraft carries autonavigators. It appears well worth while to reconsider how useful and practical a new application of an old scheme could be in this respect. The above mentioned automatic communication system lends itself quite probably to automatic direction finding on the ground and perhaps to ground derived distance measuring. This, combined with telemetered static pressure, provides instantaneous three-dimensional position determination. For most geographical areas the obtainable accuracies will probably be sufficient. In areas of dense air traffic, ground radars must supplement this scheme.

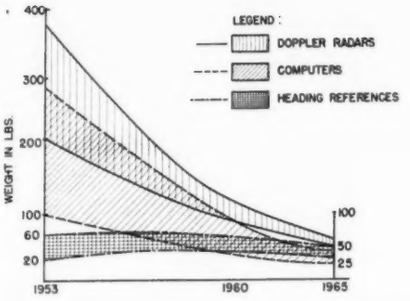


Fig. 8. Development of weights (in pounds) for components of Doppler navigators from 1953 to 1965, shown for Doppler radars, computers and heading references.

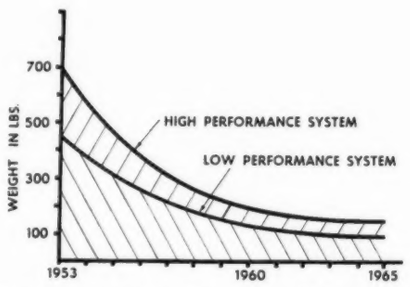


Fig. 9. Development of weights (in pounds) for complete Doppler navigation systems from 1953 to 1965, for high performance systems (top curve) and low performance systems (lower curve).

5. If a certain percentage of aircraft can afford to carry navigation receivers such as VORTAC or TACAN, thus having their own airborne means of checking and position fixing, it appears possible that *the ground can supply the checking and fixing functions for those aircraft which cannot afford to carry supplementary dual equipment*. The capacity of the automatic communication system seems to be sufficient to retransmit corrections from the ground to a certain proportion of the aircraft. A standard coordinate system is a prerequisite for this procedure. To prove the validity of this scheme, additional statistical analysis, possibly by machine simulation, will be required.

6. *Identification of aircraft on radar scopes* is still a very troublesome problem. Despite modern progress in beaconry and ground radar improvements, there are still identification difficulties in areas of dense traffic. However, it is precisely in these areas that ground radar is of the greatest use to air traffic control. With the above mentioned combination of equipments, this problem could also be considerably alleviated.

7. The scheme so far described would considerably reduce the burden on the enroute controller. In addition, where density of traffic justifies it, automation in the control center could be introduced, permitting computing machines of less complexity.

8. To reduce controller work load, radar scan speeds and communication density in the airport vicinity, similar flight patterns should be introduced in instrument weather as are used in visual flight. Attempts to accomplish this with complete ground control by radar have resulted in complex equipment or low capacities. It seems possible that autonavigators, fix-corrected at the entrance to the terminal zone, can provide flyable patterns. Radar checking could then be reduced to monitoring.

9. *Air-to-air collision warning:* I have attempted to describe a possible scheme for air traffic control and navigation, in which a number of functions are covered by overlapping techniques. Reliability and safety will be obtained by proper integration of the instruments used. It is quite clear that some kind of collision warning equipment, even if far from meeting published requirements, can well have a place in this scheme.

*

In conclusion, I should like to state that I have no doubt that self-contained navigation systems will play a major role in future air traffic control. I have attempted to show directions which future development might take. More systems analysis and possible experimentation with simulators are required to arrive at definite solutions.

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The Mind of Mr. Reader

Lear Incorporated too has a home in Geneva

Dear Mr. Editor-in-Chief,

I noticed with great interest your excellent feature entitled " Geneva-European Headquarters of the American Aircraft Industry " which was presented in your Silver Jubilee issue. I was, however, somewhat disappointed in seeing no mention of Lear, Incorporated.

I presume to understand that this came about due to the fact that our former Geneva Subsidiary, Lear, S.A., was recently dissolved as such. I am certain that what was not generally understood is that we are still maintaining our European Headquarters in Geneva; our function being to provide Sales and Technical Assistance to the Airlines, our Distributors, and Licensees throughout Europe, the Near and Middle East, and Africa. Our offices are in the same location at the Airport where we maintain our Sales and Technical staff.

I would sincerely appreciate it if you could in some way help clarify the misconception that " Lear doesn't live here any more ". We are very *much* here, alive, and kicking!

Cointrin Airport
Geneva

WILLIAM P. LEAR, JR.

Mr. Lear has every reason to feel neglected. In the rush of preparing Interavia's *Jubilee, the Editors unfortunately overlooked the fact that the Geneva office of Lear Inc. is still active and is headed by William P. Lear Jr., son of the company's founder. They can only add their sincere apologies.* — Ed.

Back to electro-gravitics... after all

Sir,

I read in the June issue that *Interavia's* editors regard the subject of electro-gravitics as closed, following the receipt of an excessive number of fanciful letters in response to the famous article by Intel. But is not this condemning the subject a little too hastily?

The article in question was obviously destined to excite curiosity. As I wrote you two years ago, its author had probably used reports published in the " New York Herald Tribune " in November 1955, adding a bit of science fiction. Incidentally, it is this science fiction, or shall we say " flying saucer ", side which discredits gravitation research in the eyes of many. Such research is being made, however, and is probably making progress. I alluded to it in the brief article you were good enough to publish in December 1956. Incidentally, you can see here the effect of the difference in tone. I have practically never received fanciful letters, although my article in *Interavia* has several times been quoted, even in the Russian popular science review " Science's Force ".

The word electro-gravitics is perhaps premature, since it implies that gravitational attraction is of electro-magnetic origin. But after all some hypothesis has to be accepted as a starting point, since what is badly lacking in the gravitational domain is experience. This was one of the conclusions reached by the conference on the role of gravitation in physics held at the University of North Carolina in January 1957, under the auspices of the Wright Air Development Center; a conference attended by forty-five eminent specialists, including such names as Bondi, Deser, Feynman, Lichnerowicz, Rosenfeld, Sciama, etc.

By experience, we de not, of course, mean the propulsion of a flying machine. This is still a long way off, although early this year the Tass agency announced that Russian scientists were expecting to counter-balance or modify gravitational force some time in 1958 (as reported in " Business Week " for February 8th, 1958). The idea is to repeat with a higher degree of precision all the old experiments, as there is room for further research here in view of the improvements in experimental techniques. For example, the famous Institute of Advanced Studies at Princeton University is attempting to detect the possible annual variations in the gravitation constant. The experiments of Eötvös on mass-weight relationships are also being resumed. And we can also mention the anomalies in the functioning of a Foucault pendulum reported by Professor Maurice Allais, of France.

It is also considered possible to detect gravitational waves, which would greatly advance knowledge of the problem. The Air Research and Development Command is reported to have suggested that the University of Detroit should construct a 4,000-lb. disc for this purpose, to turn at the frightening rate of 100,000 r.p.m.

Somewhat similar experiments have been described to the Gravity Research Foundation, an American organization, by a certain Mr. J. E. Fisher: by rotating about himself at high speed a large permanent magnet, he claims to have detected perturbations in the neighbouring field of gravity; these, however, were very weak, in the region of 10^{-6}. But however weak such results may be, they may yet prove to be extremely valuable in indicating a direction in which increased research effort could be made.

Finally, investigations are being made into possible anisotropies in gravitational fields, and two professors at Cornell University have this year received the Gravity Research Foundation's prize for their memorandum on this subject.

If the word " electro-gravitics " is considered inappropriate, it can be dropped. But it will take more than this to dim the growing interest aroused by questions of gravitation. And when we remember the speed with which theoretical studies of fission, still a laboratory curiosity in 1939, have been translated into practical application, we can be reasonably sure that our century will see vehicles exploiting the field of gravitation, though it is as yet impossible to foretell by what means. Such development is practically mandatory if space vehicles are to be built. It is already difficult to give a satellite the correct speed, not only in magnitude but also above all in direction, to place it accurately on its orbit, even with vernier motors. In order to circuit Mars, it will be essential to make en route corrections of the inevitable launching errors, for which purpose the vehicle will have to carry " something ". Moreover, in view of the long duration of such voyages, it would be useful to have very high speeds, and hence to be able to apply small accelerations to the vehicle over a long period. There is much talk of propulsion by thermonuclear plasma or by ions for this purpose. In both cases the classic reaction principle is involved, except that only small quantities of matter are ejected, though at very high speed.

As regards the thermonuclear plasma propulsion unit, it is quite possible to make theoretical calculations, at any rate using approximate values. The most favourable case uses deuterium tritium fuel. For example, with a reaction chamber of half a cubic metre volume and with an internal temperature of a hundred million degrees, it is possible, by ejecting " hot " nuclei via a " magnetic pipe ", to obtain a thrust of some hundred grammes. But the power given off by the burning medium in the form of X-rays would be equivalent to tens of thousands of horsepower! Though the necessary shielding might be provided on the ground, in a large fixed installation, it is difficult to imagine how this could be achieved in a space vehicle which must be as light as possible. And even if the shielding were obtained, how could this power be radiated into space? The shielding would melt in a very short time under the influence of such fantastic heating.

There remains the possibility of propulsion by the ejection of heavy ions; here caesium is an excellent material from this point of view, because of its high atomic weight and its relatively good handling qualities. For this type of propulsion unit it would be necessary to design generators for several million volts, and to find some way of creating large ion currents in the order of tens of amperes, to achieve thrusts measured in pounds. The high voltage generator would thus have to furnish a considerable power.

It would obviously be much more rewarding to utilize the sun's gravitation field for propulsion purposes. Although weak, this field is by no means negligible in the zone envisaged: in the order of 0.5 cm/sec². How this can be achieved, however, is another question. Whether we call it electro-gravitics, anti-gravitation, or any other name, it is one of the great objects of research for the coming decade and should hardly be ignored.

Le Raincy (S.-et-O.)
France

LUCIEN GÉRARDIN

The Air Forces of the World : Their History, Development and Present Strength. — By William Green and John Fricker. Macdonald & Co. (Publishers) Ltd., London, 1958 (English ; 336 pages in large format; price £3.0.0.).

The work of two internationally known British aviation writers, this thorough and well-illustrated handbook gives an excellent overall picture of the air forces of 84 countries, including their historical development since World War II. Simplified maps show the geographical situation of each country's main centres and airfields; the military aircraft today in service are listed in tabular form and illustrated by typical photographs; and nine colour plates reproduce the national insignia used on wings, fuselage and tail. A very helpful feature is the index to photographs, and it is gratifying to note that the pictures used are the latest available. In short, this is a book which should not be absent from any well-equipped military or aeronautical library, and one which many politically interested readers will wish to buy privately. Ri.

Le Turbo-Réacteur et Autres Moteurs à Réaction. — By A. Kalnin and M. Laborie. — Dunod, Paris, 1958 (French; 418 pages, 280 figures; price 4,800 francs (paper back), 5,300 francs (bound).

Having both worked for SNECMA for many years, the authors are well qualified to write a book on jet propulsion and turbojet engines. The result is a well-documented analysis of all theoretical and practical considerations involved in the design of jet engines. Solutions are presented with clarity, and mathematical formulae are kept to a minimum. Abundantly illustrated (with photos, diagrams and graphs) and containing a very comprehensive table of the world's turbine engines and rocket motors, the book is an invaluable working instrument which all who are in any way interested in jet engines will want to possess. La.

Festschrift Jakob Ackeret : special volume of the Zeitschrift für angewandte Mathematik und Physik to commemorate Jakob Ackeret's 60th birthday. — Birkhäuser-Verlag, Basle and Stuttgart, 1958 (German - English - French; 777 pages; price Sw. Fr. 24.00).

It gives *Interavia's* editors great pleasure to be able to follow their brief note on Professor Jakob Ackeret's 60th birthday (in No. 4, 1958, p. 351) with the announcement of this special volume paying tribute to the well-known aerodynamicist. Their pleasure is further increased by the fact that Ackeret is an occasional contributor to *Interavia*. The book opens with a series of articles on various aspects of his career. Professor Franz Tank, former Rector of the Federal Institute of Technology, Zurich, describes his progress from his father's workshop in Zurich-Riesbach to the chair of aerodynamics at the Federal Institute, and Professor A. Betz, Chairman of the Aerodynamische Versuchsanstalt Göttingen, writes on Ackeret's years at this institute. Other contributions include "Jakob Ackeret and the Swiss Machine Industry", by Professor H. Gygi, Escher Wyss A.G.; "Ackeret and National Defence" by Brigadier Colonel René von Wattenwyl, of the Federal Military Department; "Cooperation between the Aerodynamics Institute and the Private Arms Industry" by Dr. A. Gerber, Managing Director of Contraves A.G.; and "On the Evolution of Aerodynamic Thermal Engines (AK System)" by Curt Keller, Escher Wyss A.G. An Ackeret bibliography (up to December 1957) and some sixty scientific articles by pupils, friends and colleagues complete the volume. Ha.

Technische Hydro- und Aeromechanik. 2nd, improved edition. — By Professor Dr.-Ing. Walther Kaufmann. — Springer Verlag, Berlin-Göttingen-Heidelberg, 1958 (German; 386 pages; price DM 37.50).

No more fitting summary of the second edition of this well-loved textbook on fluid mechanics and its practical applications can be found than the words with which *Interavia* greeted the publication of the first edition—now out of print—four years ago:

The book is divided into three parts, the first two of which—qualities of fluids and gases, hydrostatics and aerostatics—are very short, while the third—motion of fluids and gases—forms the major portion. This section deals with one, two and three-dimensional flows in their "ideal" frictionless form, with due regard for viscosity: continuity equations, Euler's equations of motion, Bernouilli's energy laws, Newton's elementary outline of fluid friction, Hagen-Poiseuille law, etc. Finally the principles of the dynamics of compressible fluids (gas dynamics) are described in detail, with a brief account of the problems of supersonic flow.—A standard work for students of engineering and physics, for designers of powerplant and aircraft. Ri.

Aircraft and Missile Propulsion, Volume II : The Gas Turbine Power Plant, the Turboprop, Turbojet, Ramjet, and Rocket Engines. — By M. J. Zucrow. — John Wiley & Sons, Inc., New York, 1958 (English; 636 pages; price $13.00).

The present book forms part II of the three-volume work discussed in *Interavia* for August, 1958 (p. 838, following publication of Volume I). As the main sections are numbered consecutively throughout the three volumes, the chapters here run from 6 to 10. They deal in particular with the thermodynamic cycles of the categories of propulsion units listed in the sub-title, namely gas turbine powerplants (for power stations, locomotives, ships, etc.), turboprops, turbojets, ramjets, rockets. —Like Volume I, its successor is very well documented (including somewhat outdated tables taken from *Interavia*; e.g., p. 42 etc.) and includes extensive bibliographical references. Ri.

Men and Machines : D. Napier & Son 1808-1958. — By Charles Wilson and William Reader. — Wiedenfeld & Nicolson, London, 1958 (English; 187 pages; price 35 shillings).

The gripping 150-year story of the British motor manufacturing firm of D. Napier & Son Ltd., a brief glimpse of which was given readers in *Interavia* No. 7, 1958 (p. 738 etc.), is told in full detail in this attractive, richly illustrated book. From Stephenson's "Rocket" to the Rocket Age, the activities of the company were directed by three generations of one family: David Napier, James Murdoch Napier and Montague Stanley Napier. This, of course, is the period of the most important inventions in the fields of general machine building and finally of automobile and aircraft engine manufacture, in all of which Napier has played a leading role. The reader is acquainted in detail with these pioneer achievements, and the book is a mine of information for all who are interested in the history of engineering. Ri.

Weltraumfahrt, Physik-Technik-Biologie. — By O. W. Gail and W. Petri; edited by Dr. Ernst Hofmeister. Hanns Reich Verlag, Munich, 1958 (German; 150 pages with 50 drawings and 8 plates; 2nd completely revised edition; price DM 9.80).

Some subjects discussed: Forward through recoil—the first experiments—jet propulsion—research rockets—combat rockets—satellite carriers—propellants of the future—the artificial moon—the power of gravity—the upper atmosphere—radio and sun—satellites above us—tour of the solar system—life in space—man on the test stand—existence in the void.

Der Griff nach dem Atom. — By O. W. Gail; edited by Dr. Ernst Hofmeister. — Hanns Reich Verlag, Munich, 1958 (German; 142 pages with 40 drawings and 8 plates; 3rd completely revised edition; price DM 9.80).

Some subjects discussed: The basic laws of the world—molecules, atoms, elements—the atomic nucleus—the microcosm in the atom—structure of the atom shell—atomic weights—protons and neutrons—the differences between the elements—the attack on the atomic nucleus—nuclear energy—nuclear conversion—radio-active radiation—smoke chamber and Geiger counter—the cyclotron—cosmic radiation—half-life—the first atom bombs—the atomic combustion of the stars—mesons—the hydrogen bomb—the hydrogen reactor—decisions facing mankind.

Otto Willi Gail, author of many popular science books which have been published in almost all European languages, was one of the few writers who succeeded in presenting difficult scientific and technical phenomena in a simple understandable form. It is therefore not surprising that the Hanns Reich publishers should begin their new series of popular science books with the present new editions of two of this author's works. Unfortunately it was not vouchsafed to O. W. Gail to prepare the new editions himself, as he died in 1956. However, his successors, Dr. Winfried Petri and Dr. Ernst Hofmeister, have followed closely in his footsteps and have presented a clear, scientifically correct picture of subjects of which every progressive reader would like to have an understanding. Na.

Space Flight : Space Ships, Space Stations and Space Travel Explained. — By Dr. Carsbie C. Adams. — McGraw-Hill Book Company, Inc., New York. — Toronto—London, 1958 (English; 373 pages; price $7.50 or 50s. 6d).

There can be no better way of recommending this highly informative, yet readable bok to *Interavia* readers than by quoting from the foreword by Dr. Wernher von Braun. The latter writes: "Whereas the first half of 'Space Flight' is an unusually happy blend of historical review and scientific treatise on the astronomical and engineering fundamentals of astronautics ... the second half offers a broad outlook into the future of space flight which far transcends the mere technological aspects. There is a challenging chapter on the human and biological factors in space flying, with revolutionary new concepts on feeding and air and water recuperation aboard spaceships. There is a chapter on communications in space ... and many more creative suggestions ..." *Interavia* can merely add "well worth reading". Ri.

Lexikon der Hochfrequenz-, Nachrichten- und Elektrotechnik, Volume 2, E to J. — Edited by Curt Rint. — Porta-Verlag, Munich and Verlag Technik, Berlin, 1958 (German/English/French/Russian ; 808 pages; price DM 28.75).

The full lexicon comprises four volumes and a supplement, and explains more than 20,000 technical expressions in German, complete with necessary formulae, drawings, tables and references to specialized literature. In addition, all major words and expressions are given in English, French and Russian. The supplementary volume contains alphabetical lists of all words in English, French and Russian, with references to facilitate location of the explanations in the four main volumes. Can be recommended to all engineers, technicians, technical translators, students and others interested in the fields covered. Na.

Propriétés et Applications des Transistors. — By J. P. Vasseur. — Société Française de Documentation Electronique, Paris, 1958 (French; 479 pages).

This book by Jean-Pierre Vasseur, Docteur ès-Sciences and head of the Semi-Conductors Laboratory at Compagnie Générale de Télégraphie sans Fil, continues the series entitled "Collection des Annales de Radioélectricité" begun in 1957. The seven main sections (physical principles of transistors; linear quadripoles; characteristics of transistors; linear amplification by a transistor; polarization circuits; maximum power of a transistor; background noise) discuss in full detail the properties and applications of transistors, taking the subject basically from the practical point of view and giving preference to physical explanations rather than mathematical derivations. At a time when the advantages of transistors (small volume, low power consumption, low input voltages, high shock resistance, long life, etc.) are being used to an increasing extent in industry, the present book is very opportune. Na.

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Frottement et Echanges Thermiques dans les Gaz Raréfiés, by F. Marcel Devienne, Gauthier-Villars, Editeur-Imprimeur-Libraire, Paris 1958 (French).

Publications scientifiques et techniques du Ministère de l'Air. — Distributed by the Service de Documentation et d'Information Technique de l'Aéronautique, Paris 1957/58:

No. N.T. 72: Etude critique de certains prolongements de la mécanique rationnelle — Thermodynamique et viscosité, by Henry Du Boscq de Beaumont.

No. N.T. 76: De l'influence de la solvatation des ions sur la conductibilité des électrolytes, by Luc-Henry Collet.

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Communications & Electronics Buyers' Guide ; Who's Who & Reference Book, by C. C. Gee, assisted by D. W. Dwyer; published by Heywood & Company, Ltd., London 1958 (price 5 gns.).

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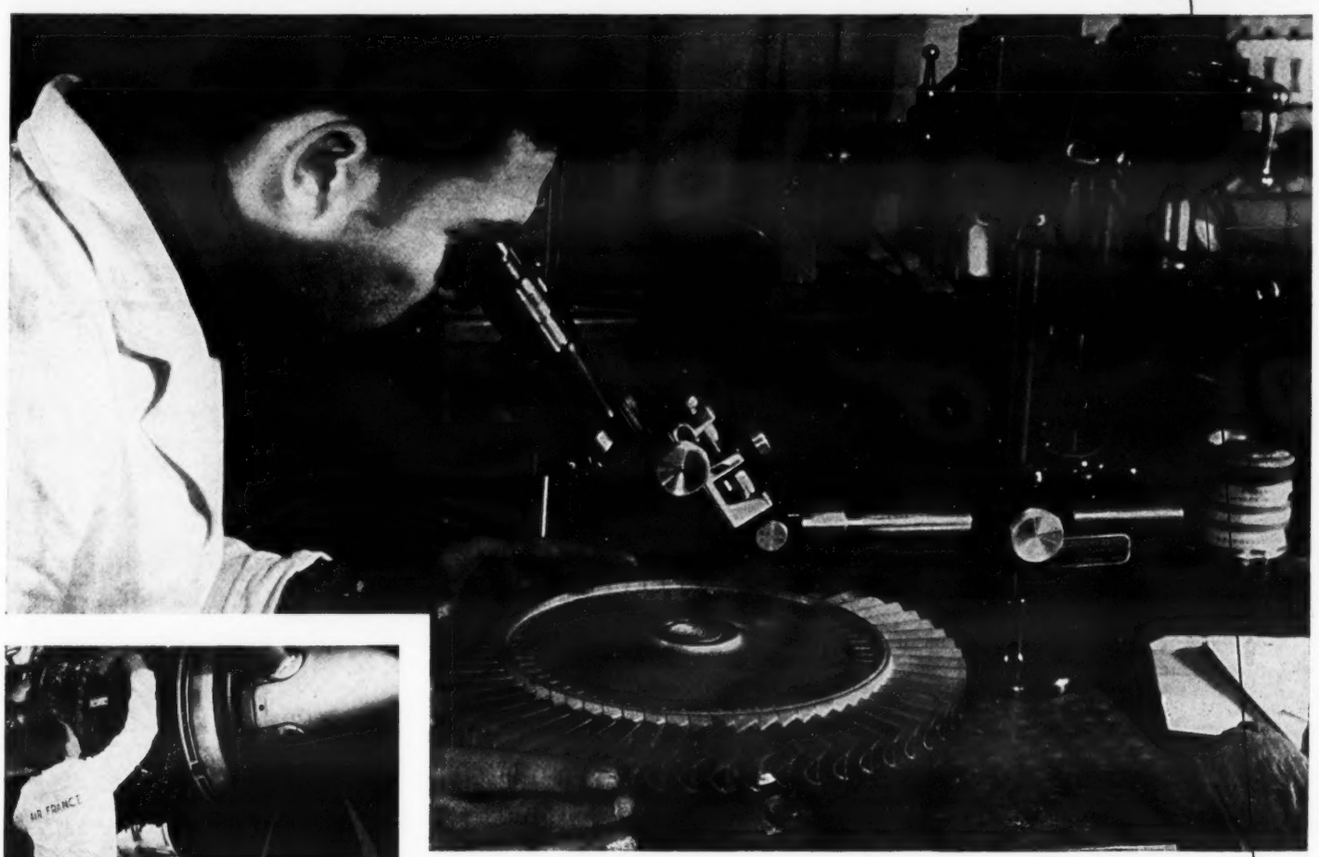

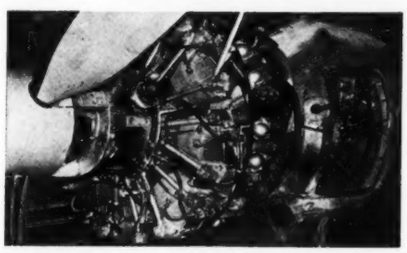

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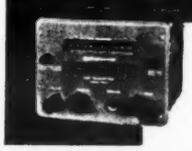

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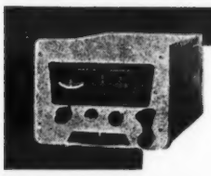

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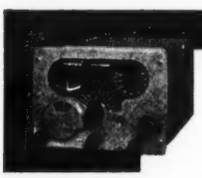

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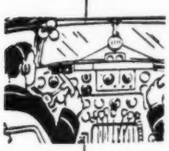

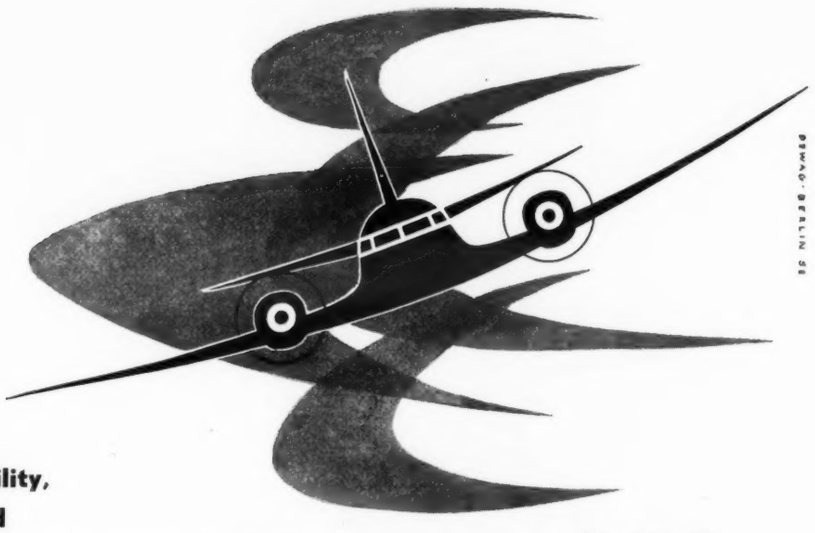

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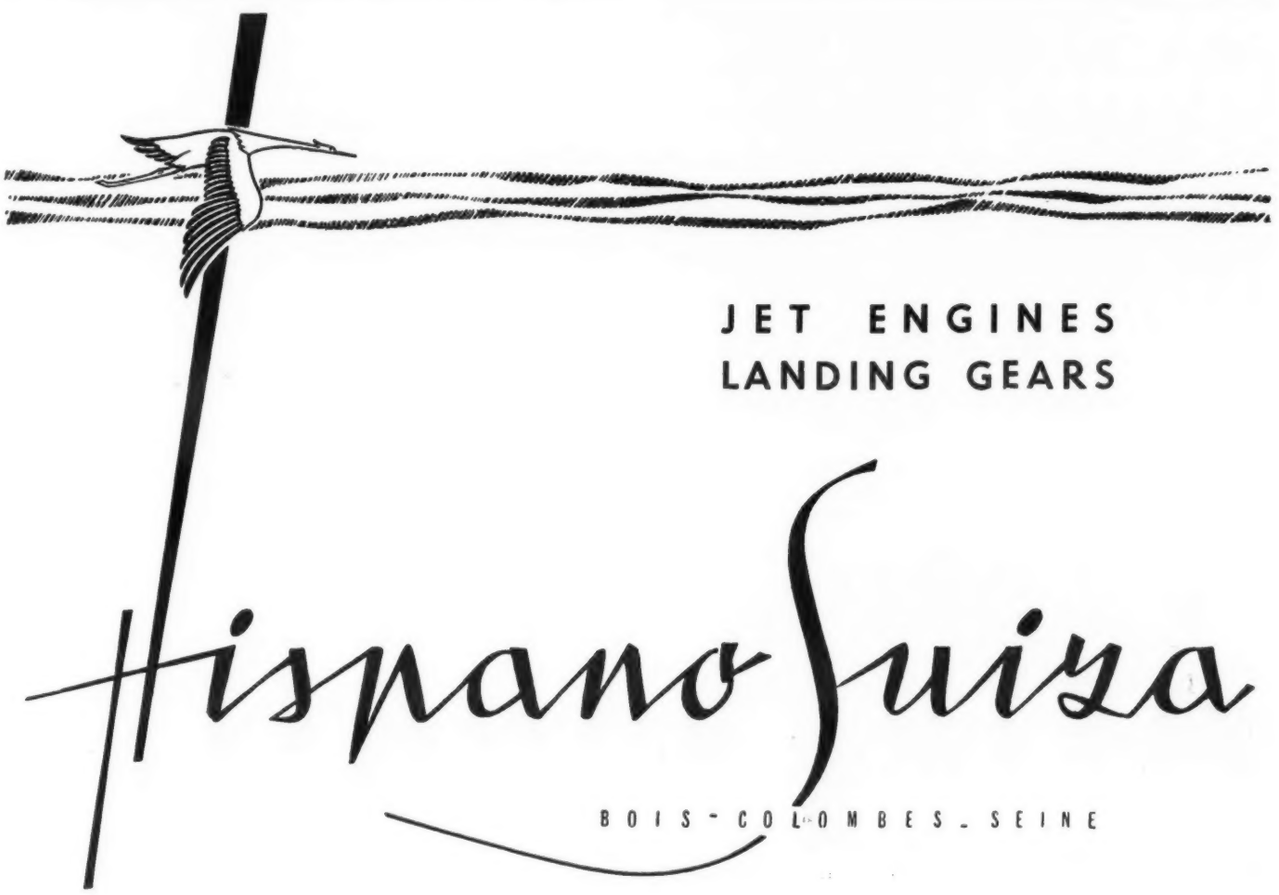

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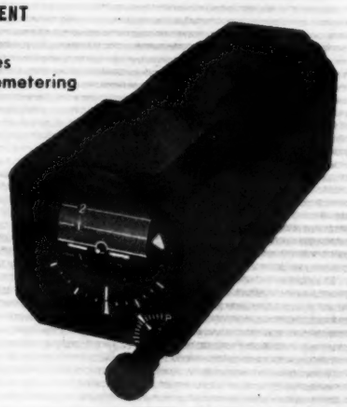

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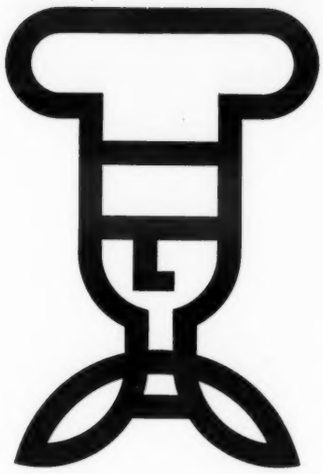

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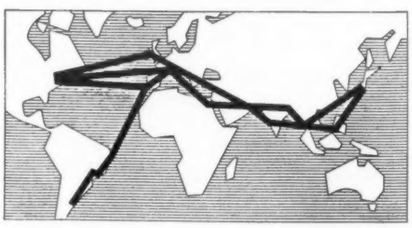

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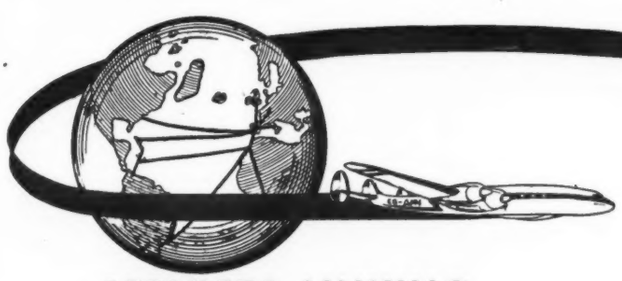

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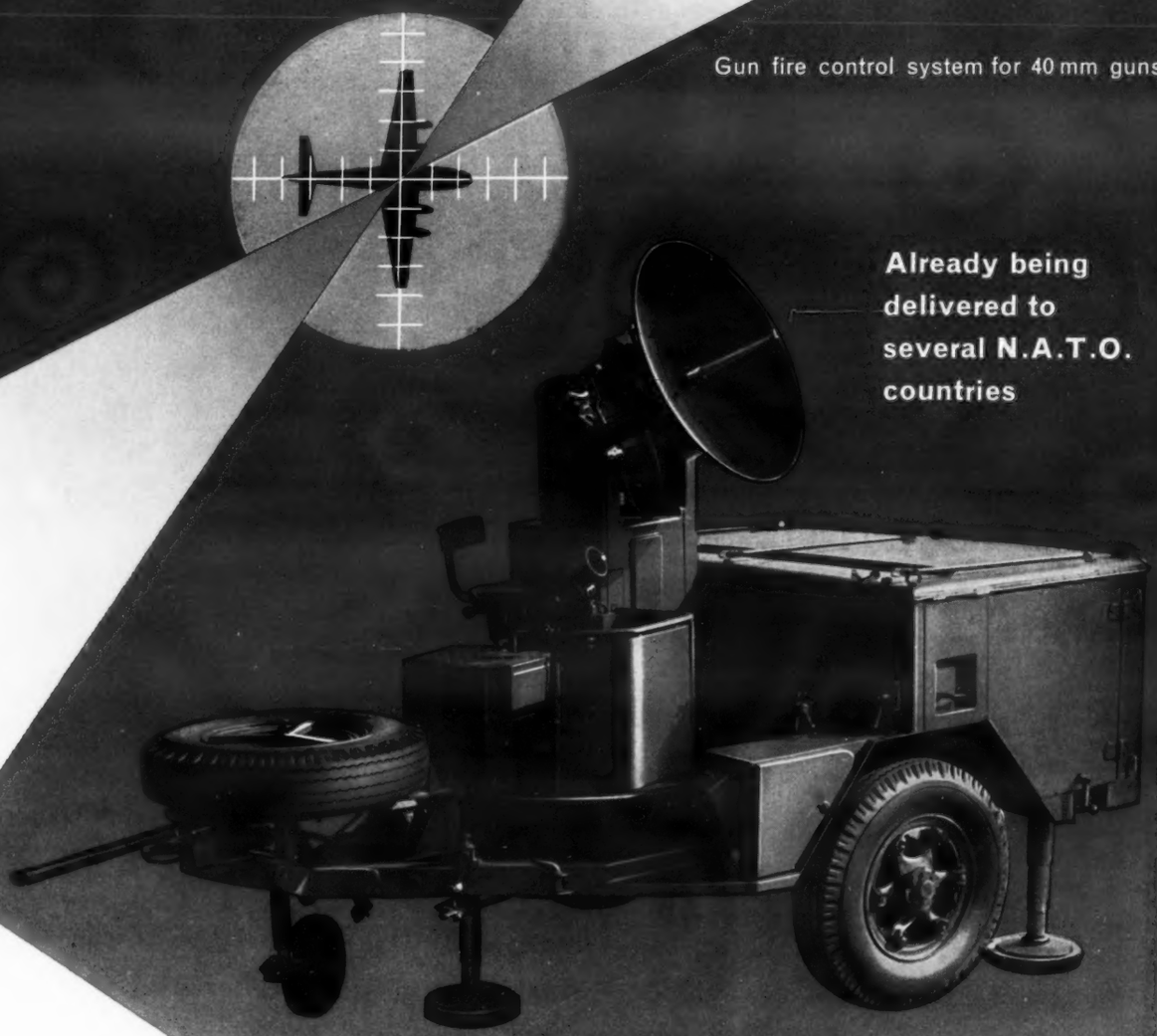

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